INSECTICIDES, FUNGICIDES, AND WEED KILLERS

A PRACTICAL MANUAL ON THE DISEASES OF PLANTS AND THEIR REMEDIES, FOR THE USE OF MANUFACTURING CHEMISTS, AGRICULTURISTS, ARBORICULTURISTS AND HORTICULTURISTS

BY

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TRANSLATED FROM THE FRENCH AND ADAPTED TO BRITISH STANDARDS AND PRACTICE

SECOND ENGLISH EDITION, REVISED AND ENLARGED

BY

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AUTHOR'S PREFACE TO FIRST EDITION

Every year the diseases of plants become more numerous, their economic importance increases, and the number of those interested becomes greater, more numerous by the means of communication established between different countries, and by more frequent commercial intercourse, more important and more dangerous because they prevent the heavy yields of different crops which should be obtained from the high farming with which the prosperity of our farmers is so closely associated, the number of those interested increases because gardening for pleasure, ornamental horticulture, extends daily more and more amongst all classes of society. It therefore becomes indispensable that the farmer, the gardener, and the amateur flower grower should possess a treatise in which they can easily find the cause of the diseases which dishearten them, and at the same time an efficient remedy capable of circumscribing them and of preventing their return.

So as to render this treatise complete in itself it was deemed necessary to pass in review the numerous experiments made up to now to suppress and prevent plant diseases.

The author has striven from the aggregate of the results reported to frame certain scientific rules which appear to determine the success of certain classical methods and to explain certain notorious failures, rules which may serve as a useful guide to future experiment and aid in the discovery of new products of greater efficiency than those now at our disposal.

The preventive and combative treatment of the diseases of plants requires a profound knowledge of the parasite as well as the product used as a remedy. Success depends on the judicious choice of the remedy utilized and the manner in which it is applied.

E. BOURCART.

Paris, 1911.

REVISER'S PREFACE TO THE SECOND ENGLISH EDITION

Dr Bourcart has done his work so well that the translator would fail in his duty if he did not insist on one point on which the author is silent, *viz.*, the enormous value of the great number of tried recipes—recipes which have passed the ordeal of a capable and wise censorship—embodied in this treatise to every one interested, whether farmer, gardener, forester or last but possibly not least the manufacturing chemist.

The years which have elapsed since this work was first translated have been characterized by considerable developments in the application of chemical science to agriculture The study of insect and other pests and the means for their suppression have been actively pursued; and, particularly, it has been sought to turn to account the knowledge of toxic chemicals derived from war-time investigations. Much of the work, however, has not got beyond the experimental stage; and it is necessary to proceed with caution, as too drastic measures may result in destroying beneficial as well as harmful organisms. In preparing this reprint, therefore, although, in part, fresh matter has been substituted for older, historical sections, the broad basis of the original work has been retained. Where new methods and recipes are given they are those which have been thoroughly tested and generally bear the stamp of official recommendation. Particularly extensive developments of the insecticide industry have taken place in the U S A., often along different lines as regards procedure and nomenclature from those followed in Europe. The huge geographical area of the United States, with its extensive tracts of swamp, lake, and forest, and generally mild and humid climate bordering in parts on the sub-tropical, favours the production of a rich entomological fauna which, however interesting it may be to the scientist, is certainly full of perplexities for the farmer. So we find a multitude of liquids and powders devised for destroying insect pests with active assistance and supervision from a paternal Government to regulate their use or abuse. The research work in the British Empire and European countries and their colonies is considerable, and is rapidly growing in importance as the regions of cultivation are extended, especially in the tropics and the warmer temperate zones. Due cognisance has been taken of these developments, but this book in its revised form remains an English translation of a French work based on fundamental principles and supported by the proofs of experience.

The entomological glossary, formerly a separate section, has now been incorporated in the body of the book, chiefly in the form of foot-notes.

T. R. B.

8 Broadway,
Ludgate, London, E.C.4
September 1925.

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INSECTICIDES, FUNGICIDES AND WEED KILLERS

INTRODUCTION

Relative and Absolute Diseases.—Plants, like man and animals, in virtue of their living cellular constitution, are liable to disturbances of their physiological equilibrium, that is, to diseases. The diseases of plants are quite as well defined as those of animals, and a certain analogy exists between them, so also with the inducing causes We again find amongst these causes the same physical, chemical, or parasitic elements. These causes generally co-operate to produce disease, but one cause is always preponderant and serves as a basis for classification. Plant diseases are divided into (*a*) *relative* and (*b*) *absolute* diseases. Relative diseases are a return to the natural wild state of the plants artificially selected and profoundly modified by man, and so it is that Brussels sprouts, turnip cabbage, and the different species of cauliflower are derived from a species of cabbage to which a disease, *Parenchymatosis*, has been imparted artificially by over-nitrogenous feeding systematically pursued for several generations. The tendency of these plants to form large fleshy buttons, in the form of a cabbage-head, or excrescence of the stem, is not at all inherent in the species, and it is not unusual in dry seasons to observe a return of these plants to the primitive condition. This degeneration is regarded as a *relative disease*. It is the same with fruit trees, we skilfully maintain by pruning the morbid condition which forces them to produce an exaggerated amount of fruit so as to accomplish in this way the end which we assigned to them. Their return to the natural state is regarded as a degeneration or a *relative disease*. *Absolute* diseases result, on the other hand, from more or less profound alteration, general or local, of the organs of the plant, from a more or less extensive and complete alteration of the cellular tissue It is to *absolute* diseases alone that the etiological observations which are about to be examined apply.

Etiology.—Etiology is that part of pathology which is concerned with the research of the origin of diseases, and examines the causes which induce them. The latter are divided into *effective* causes (those which actually cause the disease) and *adjuvant* (helping, predisposing) causes (those which place the plant organism in such a condition that the effective causes can act) In practice, these causes are confused and linked together in such a way that an adjuvant cause in a given

disease may become an effective cause in another disease. It has been seen that the etiological factors of disease may be divided into (1) physical, (2) chemical, and (3) parasitic.

(1) **Physical Causes.**—These depend on climate and season. Heat, cold, drought, and humidity, more or less sunlight, are factors which greatly influence plant growth They cause deadly plant diseases when all favourable conditions do not work together Here, as in the animal kingdom, the great law of selection intervenes Only plants able to live in the existing climatic conditions will subsist, the others suffer, fall ill, and disappear. There are few remedies for climatic causes.

(2) **Chemical Causes.**—These relate, especially, to the chemical composition of the soil, from which the plant draws the elements required for life and growth. These may exist too abundantly, or not in sufficient amount. These physical and chemical causes favour the development of parasitic diseases Plants weakened by these causes can exert little or no cellular resistance to being overrun by parasites, which find in them a medium favourable to their growth and development, for however unfavourable these conditions may be to the development of the plant, they are precisely those which favour the evolution and multiplication of parasites.

(3) **Parasitic Causes.**—The evolution of all parasites, animal or vegetable, should be well known, as they are neither injurious nor destructive to the same extent in different phases of that evolution. Each parasite has a very characteristic evolution, more or less long, always the same for the same species. (1) *Animal Parasites.* These belong to the most diverse classes, but insects especially occasion the most frequent and perceptible damage. The insect originates in the egg. The insect which it contains passes through very different conditions, until after a greater or less length of time it becomes perfect, that is, capable of laying eggs to ensure its reproduction The sequence of these intermediate conditions is called metamorphosis, and the different forms, larvæ, caterpillars, grubs, chrysalides, etc. It is especially in the larva form that the insect is most injurious. A sound knowledge of these metamorphoses, of the periods at which they take place, and the spots where they occur will render the struggle against insects at the moment of their evolution - when they are the most sensitive to insecticides and when they cannot withstand their energetic action—comparatively easy. (2) *Vegetable Parasites.* These include fungi and certain phanerogams. Fungi have also an evolution, differing greatly with the species, and often very complex. Their method of reproduction, the time and place where the spores are produced as well as the plants on which these spores can germinate, should be known. The reproduction of fungi is effected by means of spores. These spores develop when climatic conditions permitting their evolution are realized. The *mycelium* (this is the name given to the new-born parasite) can then expand, either in the interior or on the exterior of the plant which they attack. In both cases it lives at the expense of the cellular tissue, and in so doing produces characteristic diseases. Organs of reproduction are formed on the mycelium, from which spores that spread the disease are detached. The

spores produced differ with the season and locality of the plant. They are differentiated into (1) summer spores, very delicate, which generally produce a mycelium forthwith, and (2) winter spores, very hardy, which do not develop until after a winter passed as such. No general rule can be given as to the evolution of fungi. It differs as much from one species to another as in that of insects Species exist of very complex forms, the evolution of which obliges them to pass each cycle on very different species of plants. The suppression of one of these plants in the district may lead to an instantaneous and complete stoppage of the disease. These fungi are not all equally injurious. The following classification, based on their action on plants, has been adopted: (*a*) *Absolute parasites*, (*b*) *Wound or weakness parasites*, and (*c*) *Facultative parasites*. (*a*) The first, the most dangerous, are capable of attacking healthy plants. (*b*) The second can only attack the plant if its physiological condition is abnormal, *i.e.*, attacked by disease, if its *vital* energy be diminished by climatic conditions; or if hail, or frost, grub, or other cause has made an opening in the epidermis, enabling them to penetrate into the interior. (*c*) The third are the fungi formerly termed saprophytic fungi as opposed to parasitic fungi. Whilst the latter draw their nutriment from the living cell, the former live on inanimate organic matter. It has been ascertained, nevertheless, from the profound study of cryptogamic diseases that saprophytic fungi may, in most instances, become dangerous parasites if, through special circumstances, the plant cell may happen to contain elements sought after by one of these fungi. Thus the *Penicillium glaucum*, the well-known green mould, which usually grows on an inanimate medium, is attracted during the ripening of fruit by the sugar contained in the latter, and penetrating therein causes them to rot. (3) *Microbe Parasites.*—In the case of a microbe parasite it is especially necessary to know what factors induce its development, which is closely connected with the composition of the cellular substance, the temperature, and the moisture. Plants, however, suffer less from these than animals, because the reactions of vegetable plasma are acid, which are less favourable to their evolution than an alkaline medium. However, the daily discovery of parasitic microbes helps to throw light on some of the morbid phenomena of plants, and microbes appear to play a most important rôle in plant pathology.

The antagonism between animate beings, as much animal as vegetable, which live in the same medium does not give rise solely to very weak, morbid conditions, but also to relations between beings of very different species, which are advantageous to the two antagonists. These associations are termed *symbioses*. De Bary, generalizing the term *symbiosis*, distinguished (1) *Mutualistic symbiosis* or advantageous co-operation of the two associates, and (2) *Antagonistic symbiosis*, where the one lives at the expense of the other.

1. Mutualistic Symbiosis.—Many cases of evident symbiosis occur between phanerogams and cryptogams, between cryptogams and microbes, and between phanerogams and microbes. Amongst these symbiotic associations the lichens must be regarded as the most typical and the most perfect example. It is the most complete association known, where the elements, fungus, and alga are so closely associated

that henceforth it is impossible for them to live apart The most interesting cases are those of evident symbiosis between certain fungi and trees such as *Fagus* (beech), *Corylus* (hazel), *Castanea* (chestnut), and several species of *Coniferæ* In this symbiosis, known as *Mycorrhiza*, the *mycelium* of the fungus invades the roots of the tree, and, whilst borrowing the necessary elements of life from the tissues of the plant, cedes to it the nutritive elements favourable to its growth. Other symbioses of great importance to agriculture exist between certain cultivated plants and certain microbes We have, on the one hand, the *Bacteriorrhiza* of Hiltner and Stromer, in which bacteria, whilst drawing their nutriment from the cells of the root epidermis of *Beta* (beet) and *Pisum* (pea), without injuring the latter prevent injurious fungi, such as *Phoma* and others, from invading and destroying these plants. Again, microbes and *Leguminosæ* are associated together: *Rhizobium leguminosarum* (Frank) and *Bacillus radicola* (Beijerinck). These bacteria live on the excrescences, the characteristic nodosities which they produce on the roots of the *Leguminosæ*. If they draw the necessary elements of life from the cellular tissue of the root, they as a matter of compensation cede to the nursing plant nitrogen of the air in an assimilable form. These symbioses are favourable to the development of the plant, and the rupture of this association necessarily creates a less prosperous state, more akin to a grave pathological condition; the more complete the symbiosis the more the health of the plant depends on the nutritive elements with which these associates are capable of supplying it. In the disinfection of the soil by chemical agents it sometimes happens that, in destroying noxious parasites, the mutualistic parasites are destroyed at the same time, and that in curing one disease another is created. Pure cultures of these useful bacteria, or of the mycelium of mutualistic fungi, must, therefore, be spread on the fields some time after disinfection. The very contradictory results obtained on the large scale by the use of pure bacteria arise from the fact that these should be applied, not upon *any* soil, but on *a* soil disinfected by carbon disulphide The soil is like a wort, and there is a great analogy between selected leavens (yeasts) and soil bacteria The selected leavens cannot yield a result except on wort previously freed—by sterilization, by means of heat from any other leaven which would hinder their development. In the same way, the soil which it is desired to sow with mutualistic bacteria should be freed, by previous disinfection, from the elements which can, by their presence, oppose the normal evolution of these useful bacteria. Each plant possesses its own bacteria, and in each particular case requires the aid of a pure, selected, and well-defined culture of microbes.

2. Antagonistic Symbiosis.—The most common result of the antagonism between animated beings is the parasitic disease general or local—to which the plant, badly equipped, or in bad condition to resist the attack of its enemies, succumbs. The number of plant parasites is immense, and they are found in all classes of animated beings (phanerogams, cryptogams, bacteria) as well as animals (worms, insects, acari) living at the expense of the plant. They all become more dangerous, the one more than the other, in so far as they find the medium favourable to their development and extraordinary multiplication a medium

of constant and invariable composition, and climatic conditions lying between narrow limits, to which are intimately linked the growth and reproduction of each organism Between enemies the struggle is constant. The reaction of the plant against the parasites which threaten it, its cellular activity, which opposes to them its layers of bark which creates deposits of tannin, of acids in the cells, layers of wax on the epidermis, prevents it from succumbing. There is no disease until the reactive forces of the plant become powerless to prevent the development of parasites, until the disposition of the subject, and special and exceptional conditions, facilitate their evolution, increasing their virulence and their number. There is, however, disease when the parasitic antagonists imported from a foreign country (as was the case with certain insects imported from America, and as is seen in America as regards insects of European origin) are deprived of their natural parasites capable of hindering their abnormal multiplication Great invasions of parasites must be regarded, in fact, as accidents, for nature has attached to each ravager one or more parasites which live at its expense, just as it itself lives at the expense of the plant. These parasites obey the same laws as the ravagers, multiply with the same rapidity as the latter, and by diminishing their number form the check which nature opposes to the abnormal multiplication of the species. Moreover, sudden changes of temperature at the time of the casting of the skin of the larvæ of the insects —then very delicate—frosts, heavy rain, free electricity, appear to be some of the causes which hinder the development of too great a number of parasites. In nature these causes prevent epidemics, which would be very rare if man did not, by his methods of culture, create specially favourable conditions for the evolution and multiplication of parasites. Formerly, this state of affairs was remedied by the bare fallow, to-day, rotations are preferred, to-morrow, the annual disinfection of the soil by means of carbon disulphide, that of the underground and aerial (above ground) parts of plants by insecticides and anticryptogams may definitely abolish a condition which necessarily results from our methods of cropping. It will be seen, however, that the complete destruction of parasites is not indispensable, but even injurious, and that disinfection should only re-establish equilibrium, a *modus vivendi* between the plant and its parasites. It is necessary, in fact, to avoid diminishing in the plant the reactive force of the cells, so that these may always be armed and active, and able at any moment to sustain the struggle against parasites. This equilibrating disinfection is realized in the protection of the vine against *Phylloxera* [1] and cryptogamic parasites by the annual treat-

[1] Phylloxera of the Vine *Phylloxera vastatrix* (aerial and subterranean). —The adult female lays a single egg on the wood of the aerial part of the vine called a winter egg The young apterous phylloxera which issues from it either immediately gains the roots or the leaves of the vine, on which it produces a characteristic gall doing little injury to the plant This aerial form or gallicole of the phylloxera is rarely found on French vines, but it is very widely spread on American vines, the roots of which are not generally invaded by the insect The aerial form of the phylloxera does not belong to the indispensable cycle of the very curious evolution of this insect. The young phylloxeras which descend to the roots prefer to fix on the radicles to introduce their dart there and to remain fixed at the same spot, continually sucking the juice of the plant.

ment (*a*) of the soil by weak applications of carbon disulphide, of dissolved sulphocarbonate, and (*b*) the aerial or above-ground parts of plants by sulphuring, multiple spraying with weak cupric bouillies, washing of the stock with ferrous sulphate (green vitriol), and by scalding or hot water treatment. The number of plant diseases increases, as now we do not solely cultivate native plants, but more and more foreign species imported into the country. The deportation of the latter places them in new conditions against which nature has not armed them; and in the country of their exile they are defenceless against parasites. But these plants import parasites which find a favourable medium for their evolution in the plants of their new country, against which the latter are not armed.

Therapeutics.—Therapeutics is that part of medicine which treats of curative agents and studies the manner of using them in the treatment of disease *Vegetable therapeutics* is based on physiological data on the knowledge of the physico-chemical properties of curative agents, on their action (1) on the plants to be treated, (2) on the factors which cause the disease. It will therefore be necessary to indicate in the case of each chemical product used in the treatment of plant diseases (1) the process of manufacture of the chemical product. (2) Its physico-chemical properties, a knowledge of which facilitates the preparation of therapeutic specialities and makes known their mode of action. (3) Its use in human medicine. (4) Its action on the plants treated. (5) Its action on the parasites to be overcome, or on the factors injurious to plants. Curative treatment is *surgical* when the effective causes are suppressed without the aid of chemical products, and *chemical* when recourse is had to the aid of chemical products. The use of the one does not exclude the use of the other, and the two utilized simultaneously may produce a better effect.

Surgical Treatment.—Surgery, or operatory medicine, is the part of medicine which comprises the intervention of the *naked* hand or the hand *armed with instruments*. The intervention of the hand armed with instruments has given rise to vegetable surgery, the intervention of the naked hand to the *methods of destruction of parasites* picking, collecting, trapping, baiting.

Vegetable Surgery.—Vegetable surgery has many analogies with animal surgery. An organ deeply attacked or capable of being regarded as a seat of infection should be removed in either case. That is so much the more easy in the case of a plant, as the latter is a being whose growth, by budding, is indefinite, and that the organs removed are replaced by equivalent organs in a comparatively short time. The best known process, called "phloioplasty," consists in removing in a partial or general way the old bark from the trunk and large branches of a diseased tree as far as the liber. The dressing of the wounds, which ought to be kept as clean as those of man, is done thus · If the disease be so deep seated as to necessitate exposing the wood, a protective coating, after cleaning, is spread on the surface of the wood, which preserves the wound from contact with the air, but if there be a living piece of bark (parenchyma, cortical fibres, or liber), whether in the heart of the wood or on its edges, it must be respected and protected by some folds of the suberose layer. In this latter case,

the application of a coat of tar would be fatal, especially if used hot. The artificial wound method is practised to restore health to a tree whose bark is invaded by *scolytus* Longitudinal incisions are made on the parts attacked, penetrating the cortical layers only as far as the liber. In serious cases, a narrow band is removed from the suberose layers This superficial incision induces a flow of sap, leads to the formation of new tissue, and stops the transversal progress of the larvæ of the *scolytus*. If the tree has been invaded in all parts by scolytes, the great part or even the whole of the circumference of the tree is decorticated but so as not to wound living tissue. When the strips are removed, hems are formed, when the tree is completely decorticated, a network of cortical fibres is seen to form on the surface, the diameter of the tree grows, and a new bark is formed. Surgical interventions of this kind, although rarely employed, may be useful when chemical treatment has no effect.

Methods of Destroying Parasites by the Naked Hand.—When a parasite is of appreciable size, and especially when it forms visible and accessible colonies, its suppression by catching gives immediate results On a large scale the parasites may be induced to localize themselves in spots where their destruction is easy. According to circumstances the methods used are (1) Picking or catching, (2) Traps or baits.

Picking and Catching.—Coleopterous insects (cockchafers), grubs of butterflies, especially when they live in colonies, the agglomeration of eggs of certain Bombyx [1] (Ocneria) are picked. This picking is generally done by hand. However, when it is desired to pick small insects rapidly, tinned iron funnels with a wide mouth are used, above which the infected organs of the plants are shaken. The neck of the funnel is connected with a cloth sack into which the parasites fall. The destruction of insects on farm land is also accomplished by aid of poultry. For this purpose there are portable hen-houses, which are drawn into the middle of the fields. The poultry wandering about at will soon free the plants and the soil from parasitic insects. It is a very cheap, useful and ready method at certain times of the year.

Traps and Baits.—To facilitate the collection of insects and their larvæ artificial shelters fixed on the plants have been tried. The trunks of trees in autumn have been girdled half-way up with undulating cardboard bands of about four inches wide or with bands of straw. All the insects which hibernate as perfect insects take refuge there. All that has to be done is to remove and burn the refuges This process is of frequent use in Germany to destroy the vermin of fruit trees.

Traps fulfil the same purpose as shelters, they draw the insects to a certain point and render them more accessible for destruction. When a polyphagous (omnivorous) insect has a marked predilection for a plant, trap-plants are sown between the lines of the crop. The insects prefer to seek the trap-plant, on which it is easy to collect them or

[1] Bombycides.—Nocturnal moths, heavy and squat in shape, with a body abundantly covered with hair, the wings are at rest, sloped like a roof. The caterpillars almost always bristle with numerous long hairs; they spin cocoons to transform themselves into chrysalides.

destroy them by energetic chemical means, destroying both the insects and the trap-plant at the same time. The larvæ which ravage the plants in the soil may be destroyed by analogous methods. Fleshy roots or tubers are buried in the soil between the rows of the cultivated plant which are removed when the parasites have chosen a domicile there. *Nematodes*[1] and grey worms, which are polyphagous but have a marked predilection for certain tubers, are destroyed in this way.[2] Lantern-traps are used to destroy winged nocturnal parasites, butterflies, and coleoptera. They form luminous fires which attract the moths at night. Acetylene lamps fitted with a reflector and surrounded with a plate coated with birdlime retain the nocturnal visitors. This process is used in viticulture in which it helps to lessen the Pyralis[3] and the Cochylis[4]. Therapeutical surgery is therefore chiefly used to combat animal parasites.

Beneficial Insects and Parasites—One means of destroying pests is by the encouragement of organisms which prey upon them. This branch of research is being vigorously followed and in many cases has met with a considerable amount of success. To quote a single case, which could be multiplied indefinitely, the Pentatomid, *Perillus claudus*, is one of the most important predaceous enemies of the Colorado potato beetle (*Leptinotarsa decemlineata*) in its original home, about the eastern foothills of the Rocky Mountains, and has gradually spread eastward with it. For the last twenty years this bug has kept *L. decemlineata* in check in Michigan; the arsenical sprays used to control the beetle do not destroy the bug. Care needs to be exercised, however, in displacing the "balance of Nature," as unexpected results sometimes follow. A case is recorded, for instance, in which a colony of *Coccus* (*Lecanium*) *hesperidum*, L., on oleander was destroyed by the Chalcid parasite, *Coccophagus scutellaris*, Dalm. Subsequently the dead scales provided a breeding-place for the more harmful species, *Pseudococcus adonidum*, L., which otherwise could not have obtained on the smooth leaves the refuge it always needs. However, useful parasites now run insecticides close and at any rate constitute a powerful second line of defence. Ichneumon flies are chief among the bene-

[1] NEMATODES or eel worms are small worms of a filiform aspect, a smooth tegument, which live in the interior of plant-tissue, causing characteristic deformations of the organs attacked.

[2] *Translator's Note.*—As many as 150 wire-worms have been trapped by rape cake, etc., 2—3 inches underground close to one hop hill by Whitehead.

[3] PYRALIS OF THE VINE.—Tortrix, 1 centimetre long, of a more or less gilt yellow. The eggs hatch in the end of August. The caterpillars hibernate between the fissures of the props and under the bark in a small case of white silk which they spin. In the following May they quit their cocoons and gnaw the young buds, they agglomerate the small nascent leaves with silk thread, thus preventing the buds from expanding; moreover, they encircle the small grapes with a silky envelope inside which they shelter.

[4] COCHYLIS AMBIGNELLA (cochylis of the vine, the vine tortrix). This small tortrix is about half the size of the pyralis of the vine, its length is 8 millimetres. The upper wings are yellowed, crossed by a wide brown band. The under wings are grey. Two generations annually. The caterpillars of the first generation invade in May the young vine shoots of the vine in flower, of which they eat all the parts, the vine shoots which escape in the spring are afterwards attacked by the caterpillars of the second generation which invade the shoots at the time the grape ripens.

ficial insects in agriculture and gardening, and there are several thousand British species of these insects The *Aphidius* ichneumon attacks the aphides which infest corn ears, while the cabbage ichneumon fly keeps down the number of cabbage white butterflies. The larvæ of these butterflies devastate crops of cabbages and other green vegetables and the ichneumon fly lays from 20 to 50 eggs in one caterpillar—and the ichneumon grubs after feeding on and killing the caterpillar emerge and spin small yellow cocoons on the cabbage leaves during the summer, and on a wall or fence in the autumn. Fig. 1 shows three clusters of these cocoons photographed to the natural size, and whenever cocoons of this description are found they should be left undisturbed or preserved carefully—as ichneumon flies form the best protection for vegetable and garden crops.

In English gardens growers of green vegetables suffer from the ravages of the larvæ of the cabbage butterflies The best remedy is hand picking, but, fortunately, their number is kept down by ichneumon flies, which lay their eggs in the bodies of the caterpillars, which

FIG. 1.—Three batches of Cocoons of the Ichneumon Fly which should be protected.

die after providing food for the larvæ of these flies. When batches of yellow or white, silky cocoons as illustrated are found on walls, fences or plants they should be carefully protected—as these cocoons are of great value to the vegetable grower. Other beneficial insects in England are hover flies, lacewing flies, and ladybird beetles.

Chemical Treatment.—Cryptogamic diseases require chemical treatment, for it is a case of overcoming organisms so infinitely little that the eye can often only see them with difficulty.

Curative Treatment.—The chemical treatment consists in placing the parasites in contact with substances which have an injurious effect on them.

Insecticides are used to kill insects, *anticryptogamics* or *fungicides* to combat parasitic fungi To get the best results from the use of chemical reagents, it is desirable to know the properties of the curative agents and the right method of using them

Examination of Curative Agents.—The chemical products utilized in the struggle against parasites ought to respond to the following different requirements: (1) To destroy the parasite or arrest its evolution. (2) To be more poisonous to the parasite than to the plant.

(3) To preserve their poisonous properties for a certain time and to adhere sufficiently to the organ of the plant. (4) To enter into intimate contact with the parasites or their elements of propagation.

Action of Chemical Products on Parasites.—Most of the chemical agents employed against parasites act chemically on their vital substance. The most active are in general those which form inert derivatives with it, which precipitate the albumen or which modify the plasma; such are corrosive sublimate, formol, copper salts, phenols, etc. They thus arrest, temporarily or definitely, the evolution of parasites or their elements of propagation. In the case of bacteria the phenomena of destruction may be more easily observed. It is then observed that their evolution and reproduction are arrested by the formation of an inert layer around them. It suffices often by prolonged washing of these bacteria with appropriate liquids to remove the immobilizing layer and to allow them to resume under normal conditions the sequence of their uninterrupted evolution. The chemical agents do not therefore necessarily kill the parasites and their organs of propagation; often they only paralyse for a certain time the normal evolution of the parasite. The more the therapeutic agent is capable of insolubilizing albumen, or of modifying the substances constituting the cells, the more active it is. Wuthrich examined the comparative action of various substances on the different spores of fungi. His researches, in which mention is made of the relation which exists between the molecular weight of the chemical products and their action on parasites, leave no room for doubt on the subject of the similarity of the action of various chemical products on the vital substances of parasites. Other poisonous chemical products act on parasites, some in virtue of their properties as solvents of organic matter, such as the caustic alkalies, alkaline soaps in aqueous or alcoholic solution, and certain acids, others by their dehydrating action exerted chiefly on the medium on which the parasite lives. No parasite living in an aqueous medium can develop except when the amount of water contained therein does not descend below a minimum. A disease may be stopped if the conditions of existence of a parasite be modified in this direction. Other chemical products are *asphyxiants:* impalpable powders, and oils and fats; they obstruct the respiratory passages.

Action of Chemical Products on Plants.- The chemical products used to combat plant diseases have all, to a certain extent unless insoluble, an injurious action on plants. The plant is generally less sensitive to chemical agents than the spores of fungi, and more sensitive than insects, their larvæ, and their eggs.

Liquids Spread on the Surface of Plants may penetrate therein by *endosmosis*, whilst gases and vapours do not appear to be, or are with difficulty, absorbed by the plant.

It follows that the treatment of plant diseases may be preferably done—

1. *By products under the form of gas or vapour.*
2. *At a time when the organs which permit endosmosis no longer exist, and when the cellular activity of the plant is reduced to a minimum, that is to say, in winter.*

At that time of the year chemical agents of any degree of concentration may be used without injuring the plant, whilst in summer infinite precautions must be taken not to destroy the organs of the infected plant at the same time as the parasites. Treatment by gas is very efficient, and is becoming more common every day, whether it be the treatment of the part of the plant above ground (aerial), or of that underground, the roots being infected as frequently as the stems by parasites injurious to their normal evolution. With this end in view injections of carbon disulphide, petroleum, benzene are made into the soil, and by enclosing (*clochage*) the part above ground, an atmosphere may be created charged with sulphurous acid, carbon disulphide, prussic acid, nicotine, etc. When solutions or emulsions of the chemical agents are to be used in spring and in summer, the sensitiveness of the plant towards these ingredients must be known. Each plant possesses its own particular sensitiveness towards substances poisonous to parasites, and it is desirable to use these substances, in each instance in an appropriate degree of concentration. When the sensitiveness of the plant is greater than that of the parasite, there is reason to abstain from the use of such substances, or it is then necessary to follow the spraying by washing with pure water, only giving them the time required to act on the parasite. This latter precaution allows the use of strong doses of toxic substances, doses which would kill the plants if the washing did not intervene to prevent prolonged contact.

Indispensable Properties of the Chemical Agents.—The chemical agents should be of such a nature as to guarantee reaching the parasites. Certain insects and their larvæ are covered with hair and down, or even with a coat of wax, which prevents aqueous solutions from reaching them. The insecticides which should be employed in such cases are alcoholic, ethereal, or oily solutions, soaps and caustic alkalies having a solvent action on the organs of protection, and capable of moistening them, so as to let the toxic substances penetrate as far as the sensitive organs of the insect. The treatment should often be curative and preservative, and it is then necessary that the substances used should persist for the longest time possible on the surface of the plant. This problem would be easily realized if rain did not remove in a short time the deposit of substances created by spraying Attempts have been made to protect plants from the effects of the natural washing by the use of substances of poor solubility in water, and with a perfect adherence to the organs of the surface treated. The agents only slightly soluble in water spread on the surface of the plant, in the form of *bouillies*, form deposits which the rain cannot remove owing to their own adherence, or to an adherence acquired artificially, by the incorporation of gluey substances, insoluble in water (silicate of soda, saccharates, soaps, gelatine, rosin). But care must be taken not to use too insoluble substances and in too great quantity, for there is a risk of covering the whole of the respiratory surface of the leaves with a layer rendering the exchange of gases impossible, which, if it does not cause asphyxia, produces at least an annoying disturbance in the growth (evolution). The insoluble, or the only slightly soluble products are, in general, of greater service than the soluble products.

In addition to their less injurious action on the plant, they persist longer on the surface of the vulnerable organs and their action is of longer duration.

The insoluble products are intended to poison insects through the stomach. A slight layer of arseniate of lead, or of arsenite of copper (Paris green),[1] on the leaves penetrates into the stomach at the same time as the leaf and kills the insect In the case of cryptogamic parasites, slightly soluble substances are used, which in contact with the dew causes it to become toxic, owing to the traces of poison which it has dissolved, and to kill the spores, which require its aid for their evolution Briefly, it is necessary in each particular case to choose the appropriate remedy and to use it with discretion It is the most difficult side of vegetable therapeutics. The therapeutic store contains a great number of products the action of which is analogous Those which can be usefully employed can be reduced to a small number. The most interesting are carbon disulphide, Bordeaux bouillie,[2] lime, sulphur, sulphate of iron, sulphuric acid, emerald green, soap-emulsions of petroleum and alcohol, tar, prussic acid, nicotine, and nitrobenzene. The greater number of the chemical products which have been the subject of experiment against the diseases of plants are, nevertheless, dealt with in this treatise, and deductions drawn from the aggregate of the results obtained by the experimenters. The results which have been published are so very different, and the opinions expressed so contradictory, that the author has been obliged to control the facts by personal experiment before expressing an opinion. Laboratory experiments do not always permit of the conclusion that their results will be confirmed in actual practice, parasites have natural means of protection which are awanting in the laboratory, but which enable them in a natural state to escape very often from the deadly action of the agents used. Experiments, therefore, to which most weight is attached are those made in practice. According to their mode of action and their nature, chemical agents are used and applied in very different ways.

Methods of Using Chemical Products in Treating the Diseases of Plants.—Insecticides and anticryptogams are used in three forms: (1) As gas (2) As powder. (3) In the state of solution or suspension in a liquid vehicle. *Use of Chemical Agents in State of Gas*—Gases are used in closed spaces under a *cloche*[3] or in the soil. For this purpose there is utilized either liquids which evaporate at the ordinary temperature or solid products which disengage gas by heat, combustion, or chemical decomposition. In any case it is necessary that the gas mix perfectly with air and reach all the corners of the area to be

[1] *Note by Translator.*—Arsenite of copper is not Paris green but Scheele's green Paris green is our emerald green, the aceto-arsenite of copper

[2] The translator has retained the French term "bouillie" throughout. The usual English rendering of the term as "Bordeaux mixture" being, in his opinion a poor rendering. All bouillies are perforce mixtures, but only a few mixtures are bouillies.

[3] *Note by Translator*—A bell- or dome-shaped glass vessel familiar to those who dabble in the French style of gardening recently resurrected in Great Britain but well known to London market gardeners at least 150 years ago, who even in those early days used them by the hundred.

disinfected. In closed spaces that is comparatively easy, in the soil it is more difficult to realize

Underground Treatment.—Injections of volatile liquids are made in the soil at suitable depths by means of an instrument called a soil *injector* (Fig 7), when by sprinkling the soil with water the gas which is disengaged is enclosed When such treatment is carried out with the necessary care, so as to avoid the contact of the liquid substance with the roots of the plant it yields perfect results But difficulties are encountered due to the nature of the soil. If it be easy to disengage toxic gases in a friable soil it becomes difficult to spread the gases uniformly in a compact wet soil Gases circulate with difficulty through certain soils, and are not retained long enough in others Water creates an impenetrable barrier to the circulation of gases The gases produced in the soil should not enter into reaction therewith and be fixed by the substances in the soil. From this point of view carbon disulphide is the best substance. Other substances, such as tar, petrol, benzene, sulphuretted hydrogen, are retained by the capillarity and chemical action of the soil which often energetically opposes their distribution. To avoid failure it is well to give the preference to insecticides in dilute solutions in winter, and to volatile insecticides in summer, when the soil is dry.

Aerial (or above ground) Treatment by Gases.—*Clochage*, or treatment in a closed space, gives the most certain results, and does not exert an unfavourable influence on the development of the plant. Highly poisonous gases may be used against parasites, because they do not generally have a deadly action on the plant, especially when contact with the plant is not prolonged beyond measure, which result is obtained by aerating after a predetermined time.

Clochage is used to disinfect the vine by sulphurous acid. The stock is covered with a *cloche* made of a tun (cask) cut through the middle, or with a zinc receiver fitted with two handles Under the *cloche* the gas is disengaged by combustion or by chemical decomposition of certain salts: sulphur is burnt, or potassium cyanide is decomposed by sulphuric acid. The operation is finished in ten minutes. In greenhouses or in closed spaces made around fruit trees or against espaliers with waterproof awning, the operation is performed in the same way. In all cases where disinfection by gas is possible, it ought to be applied as a process sure to disinfect without injuring the plant treated. It is the only process applicable to food warehouses. Treatment by gas is always curative When this treatment is not applicable recourse is had to treatment by boiling water or solutions of toxic substances, emulsions, or pulverulent products.

Scalding or treatment by boiling water finds a very extended use in winter to kill by heat all parasites and their germs lodged along the trunk of a plant But that is a winter treatment which cannot be applied in summer, the delicate organs of the plant not being able any more than the parasites to support contact with hot water.

Use of Chemical Agents in the Form of Powder.—Non-poisonous but asphyxiant powders are used such as they are; toxic powders are reduced more or less according to the intensity of their insecticidal or sporicidal capacity with flour, talc, chalk, or any other inert matter,

finely divided and cheap The powders are projected on to the plant by means of bellows called sulphurators (Figs 5 and 6) Powders may be projected where liquids cannot penetrate. Liquid treatments are sometimes alternated in the struggle against stubborn diseases with pulverulent treatments of the same composition.

Use of Chemical Products in the Liquid Form.—Poisonous substances in a state of solution are used in both the external and internal treatment of plants. In the external treatment the poisonous substance is spread on the plant, whilst in the internal treatment it is introduced into the juice, either by causing it to be absorbed by the roots or by injecting it into the trunk. External treatment is most generally used, and it is from it that the most successful results are to be anticipated.

External Treatment: Liquids.—Solutions, bouillies, emulsions are much more used than gases and powders owing to their easy use. These preparations are distributed by means of spraying machines when the treatment is general, and by the brush when it is local. The efficiency of the treatment by liquids depends to a great extent on the mode of application. The substances should be projected in a finely divided state, best in the form of a mist, because it is less important to accumulate large quantities of substance in a given point than to spread a little everywhere in a uniform manner, above as well as below the leaves, on the twigs and on the trunks The largest number of points of contact between the spores of the fungi or the insect and the poisonous solution must be secured. The appliances which attain this object are the spraying machines which have reached a high degree of perfection The liquid preparations must possess a certain degree of concentration to be active. It is injurious to increase this concentration, and dangerous to diminish it. When a liquid preparation has a poisonous action on the plant, or if it has no adherence, these drawbacks may be obviated by multiplying the treatments with a weaker preparation. It has been found that it is better to diminish the strength of the applications and to increase the number of sprayings, for it is the abundance of these rather than the strength of the preparation which forms on all the organs, in proportion as they are developed, an extremely thin layer of a toxic substance capable of preventing the development of spores or of poisoning parasites

Experience has proven that periodically spraying at short intervals with weak bouillies yields far better results than a single annual spraying with concentrated bouillie as formerly practised. The single spraying with a 4 per cent. copper sulphate bouillie used some years ago has been replaced by three to seven treatments with bouillies prepared with 0·5 per cent. of copper sulphate Although the total amount of copper spread on the surface of the plant be mostly less than formerly, the result is better, because all the surface of the plant remains covered with a very thin pellicle of hydrated oxide of copper of which a trace dissolved in rain water or dew suffices, as has been found, to kill the spores which are germinated. This process is the more efficient because it especially guarantees against disease all the young organs of the plant, which being more tender and more

aqueous, are more easily invaded by parasitic fungi and have therefore a greater receptivity for cryptogamic diseases. The perfection of the treatment is, therefore, an element as important to secure success as the properties of the product. When anti-cryptogamic substances are used, it is necessary to bear in mind that the external treatment of a plant cannot destroy the mycelium of the fungus which has penetrated into the plant, and its multiple ramifications in the interior of the latter are perfectly protected from all outside spraying. The external treatments are intended to destroy the organs that disseminate the disease, the conidiophores and isolated spores, and thus prevent the extension of the disease to other plants. If for any reason the treatment has been deferred and the disease has assumed a great extension, it is well to remove before spraying the parts of the plant most seriously attacked and to burn them; that is a surgical complement to the chemical treatment which may be of great service and which must not be neglected if one be anxious to suppress the disease. It is well to say that neglect of one factor may compromise the results of the treatment by liquids and rob the experimental effort of any beneficial result.

Internal Treatment.—From analogy, with the treatment of human diseases, attempts have been made to introduce into the sap of the plant toxic elements, intended to be carried through the plant, and to destroy the mycelium of fungi which have invaded it, or to kill xylophagic insects and those which suck the sap. The experiments of Laffitte and Henneguy have shown that a substance dissolved in water, absorbed by the roots, may ascend to the leaves and reach the extremities of the tree if it does not form insoluble compounds with the constituent elements of the sap, however, the greater number of salts yield with the plasma insoluble derivatives, which prevent their entrainment by the sap towards the part of the plant attacked by the parasites. Numerous experiments have been made in this direction to combat the phylloxera The method used, it must be confessed with mediocre success, consisted in making a hole in the vine stock from above downwards by a gimlet, and in introducing therein the chemical agents, such as calomel, camphor, potassium sulphide. These were the first experiments carried out under very bad conditions, nevertheless carbolic acid, used by Green against lice, prussic acid against bugs, have given appreciable results The first successful results were obtained by Mokretzki with injections of a dilute solution of sulphate of iron, and nutritive elements which he injected into the sap to cure chlorosis. These were crowned with complete success. But they must be executed in such a way that the air cannot penetrate into the wound, and a slight pressure is required to enable the liquid to enter into direct contact with the sap of the plant. However, when Mokretzki tried sulphate of copper under the same conditions, his experiments were a failure. It is possible, however, that organic salts of copper soluble in the sap may behave as indifferent salts, especially if used in small doses, and produce the satisfactory effects on the health of the tree given by dilute solutions of sulphate of iron, and by sprinkling the soil with sulphate of copper. Metals are capable of forming organic salts, which no longer precipitate albumen, and,

injected into the sap, may behave in quite a different manner from the corresponding inorganic salts These organic salts have found multiple applications in human therapeutics, and it is to be supposed that their use will extend in the domain of vegetable therapeutics. The internal treatment discovered by Mokretzki will perforce extend further when it has been determined under what form poisons can be incorporated with the sap, and especially in what degree of concentration they should be used These remedies will form a powerful instrument against all sucker-lice, and will be capable of arresting the internal evolution of the mycelium of parasitic fungi But vegetable therapeutics will often yield imperfect results, in spite of all the attention brought to bear in the application of appropriate remedies, for it it difficult to dislodge or to destroy in the interior and on the exterior of a plant without injuring it the parasites which develop there, surrounded by the very efficient means of protection which nature has given them; and if we insist on this axiom, that a plant disease cannot be cured, but that it can only be diminished or its extension prevented, the important rôle which preventive methods play in the struggle against plant diseases will be understood.

Prophylaxy.—Prophylaxy is that part of medicine which deals with the means of guaranteeing against disease and preventing it. Knowing the cause or the causes of the diseases it is possible to protect plants efficiently against them. The knowledge acquired as to the reactions of the organism, and the means by which it naturally arranges to defend itself against disease, have enabled prophylaxy to utilize physiological processes instead of agents destructive to parasites. It is necessary to differentiate between therapeutic prophylaxy and hygienic prophylaxy. The former utilizes therapeutic agents, surgical processes as well as antiseptic insecticides, fungicides. The latter employs dietetics, stimulants of growth, rational feeding, selection of vigorous and hardy species Medicine in its application to plants is in fact as complicated as when applied to man, and it is not surprising to see it necessary to take at the same time prophylactic and therapeutic measures in order to have crops free from disease

Therapeutic Prophylaxy.—When the cause of a disease is known, its evolution and that of the parasites which produce it, it is comparatively easy to find the means of checking it by preventive measures. These treatments may be very often carried out at a time when the plant can bear them with impunity; in winter when the delicate organs have disappeared and when the sap is at rest. One must never wait until a disease manifests itself, even if the possibility of its appearance is not absolutely certain. Preventive treatments if they are not always capable of removing all the effective and adjuvant causes of disease will minimize them. When the cause is a parasitic one, the object pursued is not to destroy all the parasitic elements, but to reduce them to their normal or natural number increased by our methods of cropping. In these conditions, parasites having always existed and their complete destruction being as chimerical and as useless as a complete disinfection of the air which we breathe, with the object of destroying all microbes, disease is no longer to be feared, because it no longer causes us appreciable injuries.

Preventive Surgical Treatments.—Operatory medicine may be of great assistance in the prevention of plant diseases, in fact the suppression of everything which may transmit a disease from one year to another is often capable of giving radical results—excision of the diseased parts, removal of branches attacked or bearing spores or eggs, washing of the bark of the trunk and branches to suppress refuges formed by mosses and lichens for acari,[1] aphides,[2] and coleoptera. Intervention by naked hand plays a rôle not less important, by the collection and suppression of the old organs of plants, leaves, and rotten and wormy fruit on which receptacles containing the spores of fungi serve as refuge to grubs and chrysalides and as shelter to masses of insect eggs. The destruction of the parasites and their hiding-places by this simple means causes them to disappear completely after a certain time

Birdlime traps preventing insects and their larvæ from reaching points that they might ravage, are likewise useful auxiliaries. The most usual trap is the ring of tar or of birdlime with which the trunk of trees is surrounded The going and coming of apterous parasites between the leafy portion and the soil being along the trunk, the ring of sticky substance drawn round the trunk is intended to stop these often daily journeys and to retain all these parasites stuck fast An examination of the habits of parasites demonstrates that almost all are forced to use this road, some to seek a refuge in the soil for the night, others to ascend nightly from the soil in which they had taken refuge during the day. Thus the grub descends along the trunk to place itself as a chrysalis in the soil, and the butterfly, even when it is not apterous, ascends along the trunk to deposit the eggs which weigh down the female The grey worm and many moth grubs go every morning to find a refuge in the soil, to re-ascend the trunk in the evening. This method, now very common, gives perfect results. In arboriculture it is a powerful auxiliary to the liming of the tree, but it is necessary to watch that this sticky substance preserves its adhesive qualities and to renew the ring when these have disappeared. Young fruit trees being sensitive and liable to perish after an application of a

[1] ACARI, MITES, or *Plant lice*.—The acari much resemble small spiders, differing, however, by their inarticulated body Acari produce proliferations of the tissues · galls, felting, swellings, brown rust, changes in colour, leaves become yellow, red, or brown The most injurious acari are the *Phytoptus* and the *Tetranychus* (so-called "red spider")

[2] APHIS (singular), APHIDES (plural). *Naked plant lice*.—In spite of their small size, the aphides do as much damage as large insects They live in colonies, of which the individuals reproduce themselves increasingly during fine summer weather and give birth to a progeny of thousands These apterous insects remain fixed on the same spot; their rostrum, planted in the most delicate part of the plant, continually sucks the juice which flows thereto. The result of this constant irritation of the cells of the plant is that it dies, or is in a diseased state, which shows itself by characteristic deformation of the organs It will be seen that the leaves and the branches curl up, roll, swell, change colour, passing through white to yellow, to red The plant lice secrete from their cornicles (small horns) a sort of honey-dew which they eject afar and which ends by covering the whole trees with a sticky, sugary layer preventing the respiration of the plant and attracting insects fond of this sugar. Fungi of the family of Capnodium, which live exclusively on this waste, develop there and finally cover the entire plant with their black mycelium, thus causing a disease known as *Fumagine* or smut of fruit trees.

ring of tar or birdlime, it is well to fix round the trunk a strip of cardboard well fitted and to coat it with the sticky substance. The same result is thus obtained without injuring the health of the tree.

Grease-banding.—Grease-bands, consisting of strips of grease-proof paper about 8 inches in width, should be placed round the trunks of fruit trees early in October. The paper is tied at top and bottom with string and is coated with a sticky, non-drying substance similar to that used on fly-papers. This sticky material is to intercept the wingless females of the winter moth (*Cheimatobia brumata*) and the mottled umber moth (*Hibernia defoliaria*) which crawl up the tree trunks about

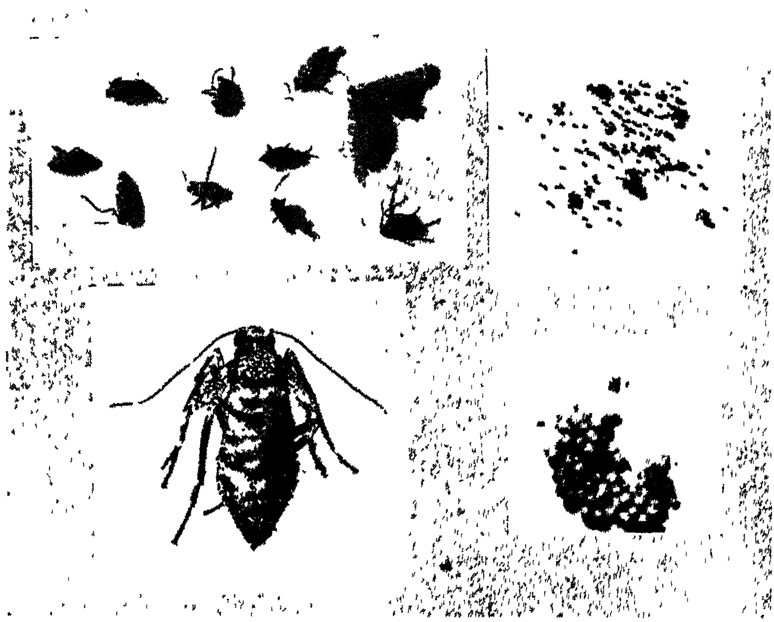

FIG. 2.—The Winter Moth.

the end of October or early in November to lay their eggs on the buds and twigs. The caterpillars hatch in the spring and at once eat up the young leaves and fruit blossom The grease-bands should be renewed in February in order to catch the wingless females of the March moth (*Anisopteryx æscularia*) which ascend the trunks in the same way in March and April. As each female winter moth lays about 200 to 300 eggs, great damage can be done to the fruit blossom if they are allowed to reach the branches.

The illustration shows several winter moths as caught on the grease-bands; a female enlarged showing the rudimentary wings; and eggs, natural size and enlarged. When laid the eggs are light green in colour, but in a few weeks' time they turn a rusty brown, and are therefore difficult to detect on the twigs and buds of the fruit trees.

Preventive Treatment by Means of Chemical Agents.—The general conditions as regards the properties of the chemical agents used in the preventive treatment of plant diseases are the same as in the curative treatment. The chemical products must destroy the parasites and be more poisonous to it than to the plant; they must adhere and preserve their poisonous power for a certain time, and enter into intimate contact with the parasite or with its elements of propagation. When such treatments are applied, as is often the case during the repose of vegetation, the comparative insensibility of the plant enables them to be used in doses deadly to the parasite without injuring the plant. Most fungi living protected in the interior of the tissue are sheltered from the action of the poisons spread on the surface of the organ attacked, and are evolved in spite of the curative chemical treatment. The important point in plant diseases is to destroy the spores which propagate the disease. To attain this result, different spores must be attacked by different methods. If it be a case of destroying winter spores, very energetic treatment must be applied in winter, for these spores have an extraordinary power of resisting chemical agents. If it is a case of killing summer spores, which, on the contrary, are very sensitive and delicate, a treatment with dilute anticryptogamic solutions will suffice. Preventive winter treatment can thus be distinguished from preventive summer treatment. Preventive winter treatment consists in destroying by chemical agents all parasites, and the elements of their propagation. To obtain this result the trunks and branches are painted or washed, after a mechanical dressing with milk of lime, concentrated copper bouillies, 10 per cent solutions of sulphuric acid, hot concentrated solutions of sulphate of iron, boiling water, petroleum, and pure carbon disulphide. These chemical agents, used in such a high degree of concentration, do not injure the plant in winter, and permit of a radical destruction of the parasites. These preventive winter treatments are, generally, sufficient to prevent the diseases from appearing in the following year, especially when care is taken to destroy the decayed organs scattered around the plant, and to disinfect the soil, the dung, and the seed. This last precaution is of an undoubted utility in preventing the diseases of plants cropped annually, and the methods usually employed have now attained a great degree of perfection. Moreover, it is necessary to destroy wild plants of the same species, which are preferred by the parasites which it is desired to destroy, plants which form seats of infection which are necessary to the cyclic development of certain parasitic fungi, such as the rust of cereals, which search for nurse plants of different species necessary for their normal evolution, and the destruction of which brings about the radical suppression of the parasite. These plants are the barberry and *Boragineæ*.

Preventive Summer Treatment.—In spite of preventive winter treatments they must be completed by summer treatments. Working so that the vulnerable organs of the plant are always protected by a fungicide very slightly soluble in the dew, the plant is prevented from succumbing to the incessant attacks of the spores, which the atmospheric currents lead to it. It is a case of very small doses of anticryptogamic agents, which suffice when the treatment is continued during the whole period in which the disease is to be feared. Weak injections of carbon

disulphide in the soil and periodic washings of the stock with dilute solutions of potassic sulpho-carbonate have given the best results in the struggle against the phylloxera, without destroying all the parasites they so far diminish their number that they can no longer injure the plant. Sulphating every year with weak bouillies yields analogous results and enables the trees to develop normally Along with the rational and periodic use of chemical agents intended to kill the greater part of the germs of cryptogamic diseases and insects, it is well to use stimulants to furnish rational nutriment to the plants and to pay attention to their hygiene

Hygienic Prophylaxy.—Vegetable therapeutics does not consist, in fact, entirely in the struggle against the effective factors, but it ought likewise to suppress the adjuvant causes. Plants are restored like animals by the art of healing regarded in its widest scope. Hygiene, which plays so great a rôle in human prophylaxy, ought to receive equal attention in the case of vegetables. This hygiene is based on a knowledge of their organs, and their mode of growth, on that of the environment where they live, and the climatic conditions which favour their development, and the mineral elements indispensable to them. It is necessary to remove bad influences from plants, and to supply them, if need be, in a regular and abundant manner with the nutritive elements which they require If it be asserted that a disease can be transmitted to a plant by artificial infection when placed in a laboratory where it has not all its means of reaction, it must not be concluded therefrom that this same plant will always succumb to this parasite in surroundings favourable to its development and in good hygienic conditions Owing to a special immunity which is not acquired, except under certain conditions, the plant, on the contrary, will be able to resist the attempts of invasion by the parasites and will issue victorious from any struggle in all instances.

Most cryptogamic parasites are incapable of attacking the living vigorous and healthy cell. Certain insects, even xylophagic, such as the Scolytes, only attack a sickly tree, the intense motion of the sap being injurious to the development of their larvæ. On the other hand, most parasites find an easy shelter in the plant when the latter is enfeebled by an adjuvant cause, or when organs capable of being invaded have been laid bare by a wound.

Stimulants of Growth—We know the favourable influence which certain metallic salts absorbed by the sap can exercise on the health of plants Salts of iron, copper, mercury, zinc, nickel, cobalt, manganese, lithium, fluorides, and arsenites have in a certain dose a stimulating action on the vital functions of the plant, analogous to that which arsenious acid exercises on our own organism The use of these stimulants may often be a useful means of stimulating the vigour of the plant, and of rendering it more capable of resisting cryptogamic diseases.

Nutrition.—The researches of Liebig, Boussingault, Dehérain, and others have shown that the development of plants depends greatly on the mineral elements which they find in the soil, and nothing is more easy than to supply them when the soil is deficient therein. The result of these researches has been intensive farming, which by supplying in great abundance the elements necessary for the growth of plants

has rendered it possible to double and triple the yield of crops. Encouraged by such success we have learned to prepare an exact account of the elements indispensable for each plant crop by the analysis of its ash, of the elements of the soil, and taking into account the nutritive elements that the preceding crop has removed and adding to the soil the elements in which it is deficient It has been observed, however, that the plants obtained as a result of intensive manuring were more subject to diseases, and that such assumed a dangerous character The great delicacy of the plants constituted a more favourable medium for their evolution, however little the climatic conditions favour their development, and predispose the plants to infection. It must be admitted that the intensive culture now practised does not produce a normal condition of the plant, but a cultivated condition, and that the parasites have acquired a greater vigour and become more virulent owing to the great richness of the plant in nutritive elements. Too abundant feeding of our cultivated plants has created a danger which the farmer of to-day must face

Formerly the method of cultivation gave a mediocre and irregular yield, and the farmer did not disturb himself Our forefathers were fatalistic as to good years and bad years Diseases existed even then, but they were not supposed to contribute much to the annual variation in the yields In our days they have a much more important rôle, for the cultivation expenses being higher, owing to increased attention and to the use of various chemical manures, the yield ought to compensate for the pecuniary efforts expended. It should be emphasised, however, that no amount of chemical doctoring can supply the place of efficient cultivation, though a judicious use of chemicals can help to reduce the increasingly high cost of labour.

Exhaustion of the Soil.—In spite of the annual supply to the soil of the elements required by the plant for its intensive growth, it is found that a time comes when the plant ceases to profit from the nutritive elements and thrives no longer. This is due to the fact that the enemies of the cultivated plant are accumulated in the soil. The alternation of crops or of different plants having consequently different parasites is now practised, and where the same plant does not appear in the rotation except at long intervals it causes a great improvement in this condition of the soil Rotations would give perfect results in the absence of polyphagic parasites · Nematoides, Elaterides, grey and white worms which attack all our crops indifferently, and the exaggerated multiplication of which operates throughout the most different crops; the spores of *Ustilagineæ* (smut, bunt, etc), which resist the weather for several years, excepted Against the exhaustion of the soil from the exaggerated development of these parasites no efficient remedy exists, except disinfection of the soil by carbon disulphide. This must be done either in a complete manner, and in heavy doses every ten years, or in small doses each autumn. It frees our cultivated fields from all the parasites which our methods of cropping have allowed to accumulate in too great number. This method finds more adherents every day, as it enables rotations to be dispensed with and to cultivate the same plant intensively for several years in succession. Artificial manures as well as the metallic salts intended to stimulate the growth of plants should

be used with discretion, so as not to predispose the plant by a modification of the sap to certain diseases which formerly it escaped. Laurent found that bacteria, not parasites of the potato in a normal state, might invade it after manuring with lime. The Jerusalem artichoke becomes less resistant to the *Sclerotina Libertiana* [1] after phosphatic manure. These two cases are easily explained, the first by the fact that the bacteria seek an alkaline medium created by the lime, the second by the fact that the *Sclerotina* seeks, on the contrary, an acid medium created by the acid phosphate Intense nitrogenous manuring favours the development of phytophthora. It is thus essential to avoid the use of manures which may place the plant in a state of subjection in the struggle which it has to sustain against inimical factors

Choice of Species.—One species may be more subject to disease than another, and possess a predisposition for certain pathological conditions. That occurs when the conditions favourable to the development of the plant are also those which favour the evolution of parasites at the time when the plant is young and possesses delicate tissues just when the parasites are most virulent. Care must be taken in sowing a plant that the germination of the seed does not coincide with the virulent development of the parasite, with the ripening of the spores of fungoid enemies, or the hatching of the eggs of certain insects. It suffices to sow a little earlier or later. But in spite of all that can be done to eliminate parasites, they none the less exist and ravage the tissues. The cells of the plant, like those of the human organism, react, and it is found that after this constant struggle they undergo certain modifications which are opposed to the development of the parasite, and the plant acquires a certain immunity It is acknowledged that the deposits of tannin and other materials in certain cells and the concentration of the sap are conditions resulting from the struggle of the plant against insects, and destined to oppose an unsuitable medium to any attempt of development. Plant diseases do not, therefore, depend solely on the presence of a parasite, but as much on the conditions predisposing the plant to a want of reactive energy, and it has been found that this predisposition was an attribute of certain species or certain varieties.

Meteorological Influences.—Although we are still badly equipped to struggle against atmospheric influences, each day brings new discoveries from which agriculture knows how to benefit. Thus fruit blossom may be protected against frost, by means of oil-flares. Without neglecting therapeutic methods it is necessary to take incessant prophylactic measures to prevent the evolution of diseases and their propagation, to treat the seed, the plant, the soil, and the crops by toxic products, to destroy the plants invaded, which form hot-beds of infection, to avoid the importation of plants from districts notoriously infected. Effort must be made to apply a general treatment to the plant, to remove as far as possible all conditions favourable to the growth of parasites. The hygiene of the plant must receive careful attention, sowing retarded or advanced; the plants protected against eventual frosts and hail; drain and lime the soil against humidity, the great predisposing cause

[1] *Note by Translator.*—Fungus which ravages potato, haricot beans, hemp, cucumbers, swedes, zinnias, petunias, chrysanthemums. *Remedy.*—Apply soot or lime to soil.

of cryptogamic diseases, apply appropriate strengthening manures, choose hardy species obtained by crossing or by selection, and create new varieties combining great resistance to plant diseases with the necessary properties of production. So that the struggle may be successful measures must be general. Each cultivator ought to be able to work in full knowledge of the cause, he ought to be able to obtain information on the nature of the diseases which he observes, and the means which should be used to combat them. All interested should be able to act simultaneously over a large extent of territory, a condition which will alone crown any individual effort with success.

If one considers that the damages caused annually to French crops by injurious insects, according to the calculations of authorized persons, amount to several hundred million francs, and that the loss due to cryptogamic disease reaches a still higher figure, an idea can be gained of the great necessity there is to generalize the methods of struggling against parasites, and the necessity of simultaneous action by all under the control and the direction of official agents. The first order dealing with the protection of crops against injurious insects is that of the Parliament of Paris of date Feb. 4, 1732; then came the Act of the 26th Ventose Year IV, which rendered obligatory the destruction of grubs in general (modified by the Act of Dec. 24, 1888). It especially prescribes the destruction of the grubs of the Bombyx *Liparis chrysorrhea*, the brown-tailed moth, the agglomerations of which in winter and in spring form silky wrappers beween the branches of fruit trees The Order declares that "After the date fixed by the Prefect, farmers who have not submitted to the prefectoral order, will be liable to a fine of six to fifteen francs, and obliged to pay to the administration the expenses incurred by it in grubbing on their domains." The panic created by the appearance of the phylloxera in 1863 was followed by an effect which has made itself felt in all branches of cultivation. Examination Commissions were formed, a National Agronomical Institute was founded in Paris. Chairs of Agriculture were created, new laws were passed, the Administration is working with equal solicitude at all cultural pests, and it has enacted the measures required to cope against the extension of diseases. As a consequence of the International Phylloxeric Convention held at Berne, an order of Sept. 10, 1884, interdicted the exportation and importation of rooted-up stocks and of sprouts (shoots). Then the destruction of insectivorous birds had been forbidden Cultivators too often misconstrue their precious collaboration in the struggle against parasites.

Societies for the destruction of parasites have been formed in cantons, bureaux of gratuitous information opened, enabling interested parties to know the disease which ravages their fields, and how to prevent it, or combat it, in the most economical conditions. These syndicates are cantonal or communal; their bye-laws must have prefectoral sanction, their budget consists of the subscription of adherents, individual subscriptions, communal, and Government grants. The Council of Administration places the instruments, the insecticides, and the anticryptogamic products at the disposal of those interested; it publishes the right times to use preventive or curative processes, and gives the detail of the methods to follow; it directs itself at propitious

seasons all the operations tending to the destruction of parasites, and to restore the fertility of the fields through the intermediary of an executive committee which has the direction and the responsibility of operations. Societies have been formed against the "Apple-blossom Weevil," against the may-bug (cockchafer, *Hanneton*). The annual results obtained by some may-bug societies in a year are as follows :—

Seine et Marne .	destroyed	282,500 kilogrammes.[1]
Brie Comte Robert	,,	101,000 ,,
Aisne	,,	13 thousand million cockchafers.
Bernay dans Eure	,,	148,500 kilogrammes

These figures are eloquent. However, if they show the useful intervention of the syndicates established for the destruction of injurious insects, they enable us to foresee the results that these syndicates would be capable of obtaining if their programme was a broader one, and comprised all which concerns vegetable pathogenesis, prophylaxy, and therapeutics. Common action organized in this way under wise direction will be a perfect method to combat agricultural pests and blights so long as no medical specialists for cultivated plants, with the same rank as veterinary surgeons, exist. But there is much ground to be traversed before getting so far as that, the science which should guide these medical specialists is only in its infancy, and the most important problems are still to be solved. It is, however, necessary to reach this goal so that this younger sister of medicine applied by special practitioners may render inestimable services to cultivation and increase the prosperity of the country.

[1] *Note by Translator*—From the peculiar style of numeration of French writers it is impossible to say whether 282,500 means 282½ kg. or 282,500 kg., that is 282½ metric tons, which seems impossible. Yet even in this country so great were the ravages of *Bombyx chrysorrhea* in 1782 that prayers were offered up in some churches for deliverance from the scourge and 1*s* per bushel was offered for the webs, and so abundant were they in Clapham parish that 80 bushels were collected in one day in that parish alone!

CHAPTER I

COLD WATER—SUBMERSION—SPRAYING HOT WATER—IMMERSION—SPRAYING—HYDROGEN PEROXIDE

Water, H_2O —Water is necessary to the plant (1) as food, (2) as solvent of nutritive matters. To a certain extent crops increase in proportion to the water used in the cultivation. Want of water injures the plant, causes deformities, anomalies, and troubles of which the chief are *pilosis,* excess of hair on the stem and leaves, formation of tart substances (piquants), stony pears, lignification of the roots; *nanisme,* potatoes with filiform rhizomes, fall of flower-buds, premature drying of the leaves, honey-dew, barren flowers in the case of cereals. But on the other hand, if water is useful and even necessary to the plant, in excess, however, it is injurious thereto. In the latter case it is the cause of the following diseases : *frisolée* of the potato, rhytidome of the potato, germination of the same plant before potato lifting, hollow fruits, stems and roots, premature formation of seeds, dropsy, gourmands, hypertrophy of the roots, cellular rottenness, frondescence, phyllodia or chloranthia, asphyxia of the seeds and roots, putridity of the seedlings

Use.—Water serves as a solvent or vehicle for most of the agents used to combat plant diseases; but it can by itself alone serve as an insecticide in many cases, and as it is cheap it is profitable to use it. Cold or hot water is used as follows, according to circumstances : *Cold water :* Submersion; spraying. *Hot water :* Immersion; spraying.

(a) **Cold Water, Submersion.**—Submersion or artificial inundation asphyxiates the insects living or refuging in the soil. It consists in placing the area of the ground to be treated under water for a period of from two to sixty days, according to the nature of the soil and the kind of parasites to be destroyed The soil must only be slightly permeable, the ground must not be on a slope, and it must be near a source of water capable of furnishing 6000—30,000 cubic metres per hectare ($2\frac{1}{2}$ acres), and to maintain it at that for a certain time. Submersion is not efficient unless it be complete, so that it may soak deeply into the inundated ground and be executed under certain conditions. The submersion of fields and vineyards is in use in different countries of the globe, and everywhere gives encouraging results. The costs of submersion are not great when near a river from which the water can be led; the expense in that case only amounts to 41 francs per hectare, say 13*s.* per acre. But when the water has to be brought by pumping machines then it may amount to 200 francs per hectare. To this amount must be added the cost of manuring, which must be abundant as the immersion exhausts the soil Submersion was recommended for the first time in France in 1864 for the destruction of insects in meadows

and fields. In 1870 the same treatment was applied to vineyards attacked by the phylloxera, and lately it has been used to render forests wholesome.

Submersion of Fields and Meadows.—The inundation of meadows and fields destroys the larvæ of Coleoptera (beetles, weevils, etc.) and the grubs of the Lepidoptera, of which the following are the most important: (1) *Melolontha vulgaris*[1] (white worm), larvæ of the may-bug (cockchafer).—Artificial inundations have been in general use in Hungary since 1888 to destroy this larva. The meadows are submersed for eight days, and after that time all the white worms have disappeared. De la Blanchere has, however, seen water remain more than a month on ground infested with white worms without these being destroyed. That is explained by the fact that the larva of the cockchafer, very sensitive to moisture, to avoid contact therewith buries itself at such a depth as protects it from inundations. But it is only in impermeable ground that the white worm has the time to withdraw itself from the action of water. In such ground recourse should not be made to artificial inundation but to carbon disulphide. During the two years of its evolution, the white worm descends into the soil in October, to a depth of about 2 feet, so as to pass the winter, beyond the reach of cold, and it is only in spring that it ascends to the level of the roots to gnaw at them. According to the habits of this insect it is, therefore, in spring and in summer that the ground should be flooded (2) *Phytonomus punctatus*, Fb.—The larvæ of this weevil are destroyed by flooding almost at the very outset. In America the cotton plantations are flooded to destroy the numerous parasites in the soil. (3) *Agrotis segetum*,[2] W.V. (grey caterpillar of the dart moth).—Flooding to destroy this insect ought always to take place in summer. In many cases flooding of the fields by the excess of moisture exerts a vexing effect on plants by retarding the ripening of the crops, or by developing adventitious plants or parasitic fungi. It is not so, however, with all crops, and it has been observed that submerged beets have more vigour and resist the fungi which ravage them better during drought, such as the *Phoma tabifica*,[3] the disease of the petiole of the leaves, the *Pleospora putrefaciens*[4] or the heart rot, and the bacillus of the *bacillary gummosis*[5]

[1] COCKCHAFERS (white-worms).—Lamellicorn coleoptera, the larvæ of which are polyphagous The common cockchafer is MELOLONTHA VULGARIS. The female lays thirty to fifty eggs in the soil, at a depth of 3—7 centimetres. They cause great damage in vineyards, meadows, beet-fields, and gardens The larvæ are polyphagous, that is, gnaw indiscriminately the roots of all cultivated plants.

[2] AGROTIS (NOCTUA) SEGETUM, the common dart moth.—The imagos appear in the middle of May. They lay in June, July, and August on all low plants, chiefly beets, at the level of the collar; two weeks after laying they are hatched. The grubs are typical: dark earthy green, two yellowish lines on each ring, four small black spots, length 5 centimetres (2 inches). They pass the winter in the ground where they bury themselves deeply; they awaken in the spring and recommence their attacks up to May

[3] PHOMA TABIFICA (beet and mangel rot).—The disease of the heart of the beet is in certain cases the result of the invasion of a fungus

[4] ROT OF THE HEART OF THE BEET *Pleospora putrefaciens*.—The rot of the heart of the beet may be produced by several fungi. That which is the most ordinary cause is the *Peronospora Schachtii*, which directly attacks the small leaves of the heart and covers them with a lilac flocked surface.

[5] GUM. *Gummosis* (bacillary of the vine).—This disease is due to the para-

of vine. These diseases being less intense after submersion the method is advantageous In the asparagus fields of the Delta region of the Sacramento River, flooding has proved quite practical as a control against centipedes in several cases, the best results having been obtained where the fields were kept thoroughly and continuously covered to a depth of a foot or more for two or three weeks.

Submersion of Forests.—Anderlind has shown the great service which the submersion of forests can render in the destruction of the insect ravagers of woods, the larvæ of which find a shelter under the moss and humus surrounding the stocks In the different countries where submersion is in use the most dangerous insects only occasion insignificant damage, it is therefore one of the most powerful preventive measures against great invasions of certain forest parasites. The following insects are destroyed by submersion: *Melolontha vulgaris*, L. (common cockchafer). Weevils injurious to conifers: *Hylobius abietis*,[1] L. (large spruce fir weevil). The Scolytides so injurious to deciduous trees. *Hylesinus*[2] *ater*, F.; *H. opacus*, Er.; *H. angustatus*, Hb.; *H. cunicularius*, Kn. The *sawflies*, very injurious to coniferæ, because their larvæ not only attack the adult needles but prefer to devour the young shoots: *Lyda campestris*,[3] L., and *L pratensis*, L., the larvæ of which bury themselves in August in the moss at the foot of trees to pass the winter there. *L. erythrocephala*, L. (red-headed Lyda), the larvæ of which hide at the foot of trees in the month of June. *Lophyrus pini*,[4] the larvæ of the second generation metamorphose into grubs in the humus of the forest after passing the winter there. *Gryllotalpa vulgaris*,[5] Latr. (mole cricket). Winter submersion has little action on it, because like the white worm it descends deeply into the ground at the approach

sitism of a bacteria The damage of the tissues consists in a gummy degeneration of the wood. It is believed that the disease enters through the pruning wounds, for this disease gains ground more especially from top to bottom.

[1] HYLOBIUS ABIETIS (the spruce pine weevil).—Brown, red-haired insect, 1 centimetre long. It appears in pine and spruce forests in May. The females lay their eggs at the foot of old trunks.

[2] HYLESINES.—These are Scolytides, which are distinguished from the bostrichus by their elongated legs and their corselet narrow in front. The larvæ and the perfect insects dig burrows in the trunks of trees. HYLESINUS PINIPERDA (the pine-destroying beetle) is a black insect, 4 millimetres, which appears in July and pierces the bark at the base of plants of a few years' growth, it there penetrates as far as the medulla and ascends the young tree, emptying it as far as the terminal bud, through which it issues. The female lays its eggs in the spring in a single sinuous burrow made in the liber; the larvæ afterwards excavate lateral burrows there. It attacks the *Pinus sylvestris* (Scots pine), *Pinus maritimus* (maritime pine), and *Pinus laricio* (Aleppo pine)

[3] LYDA CAMPESTRIS (pine saw-fly)—Black and yellow fly, 2 centimetres long, yellow wings, appears in June, and does the same damage to pines as the *L pratensis* does to meadow plants The larva buries itself in the moss at the foot of the stem in the month of August, there to pass the winter. LYDA ERYTHROCEPHALA.—The larva attacks pine needles and hides itself at the foot of the tree in June. LYDA PRATENSIS (meadow saw-fly).—Yellow and black fly, 13 millimetres in length.

[4] LOPHYRUS PINI (pine saw-fly).—1 centimetre long; head black, corselet yellow with black spots, abdomen yellow. The females lay their eggs inside the pine needles, the green larvæ gnaw the needles and weave against the leaves small cocoons of brownish silk.

[5] GRYLLOTALPA VULGARIS (mole cricket).—The mole cricket lives almost entirely on insects and their larvæ To search for this underground food it cuts all roots that hinder it

of cold. The following Lepidoptera: *Lasiocampa pini*[1] (or bombyx of the pine), the grub of which hibernates as chrysalis in moss at foot of tree *Trachea piniperda*[2] and *Fidonia pinaria*,[3] L., both hibernating in ground in the state of chrysalis. Submersion also frees the forest from the rodents which undermine it, and which in winter nibble the bark of young trees. But if on the plain the difficulties of submersion are not great, on the slopes where it is necessary to trace a series of parallel channels which flood the ground, by overflowing, this method becomes very costly, especially if it is necessary to raise the water by means of turbines or pumps.

Antiphylloxeric Submersion—In the beginning of the phylloxeric invasion in 1868, the sands of the dunes (sandhills) were found to be unfavourable to the propagation of this dangerous homoptera. The fact was observed at Aigues-Mortes, where vines planted in the dunes remained flourishing, whilst those planted in the neighbourhood died without exception According to Foëx the sands exhibited a certain immunity to the phylloxera when they contained at least 80 per cent. of silica, but a small amount of clay or limestone sufficed to deprive the soil of this precious property It was this immunity of the sands which gave the idea of submersion for the destruction of the phylloxer It had formerly been remarked that long-continued rain was unfavourable to it, and that it shunned moisture by burying itself in the soil at great depths, only dying when the soil was thoroughly soaked. Eminent vine-growers concluded that submersion might be efficient, and have submitted a part of their vines to this treatment. The results obtained were surprising The following table prepared by Faucon gives an idea of the improvement in the crop by the submersion of the vine:—

TABLE I—*Showing the Effect of the Systematic Immersion of Vineyards on the Volume of Wine Produced*

Year.	Remarks.	Wine in hectolitres	Wine in gallons.
1867	Year before the phylloxera invasion .	925	20,350
1868	First year of invasion vines fumigated, non-submerged	40	880
1869	Second year of invasion vines fumigated, non-submerged	35	770
1870	First year with submersion without manure .	120	2,640
1871	Second „ „ „ „ „ .	450	9,900
1872	Third year with submersion and manure . .	849	18,678
1873	Fourth „ „ „ „ (frost) .	736	16,192
1874	Fifth „ „ „ „ . .	1,135	24,970
1875	Sixth „ „ , „ . .	2,680	58,960

[1] BOMBYX PINI, LASIOCAMPA PINI (pine-tree lappet moth).—The female lays on the trunks of the *Pinus sylvestris* (Scots fir) in masses of 50 eggs which hatch about the middle of August. In the spring, in March or April, they re-ascend and attack the young shoots, frequently causing the death of the trees

[2] NOCTUA OF THE PINE. *Trachea piniperda*.—Imago 1½ centimetres long, head, thorax, and upper-wings, red, with yellowish-white spots and lines on the latter The abdomen and the lower wings greyish-brown The female lays in April on the needles of the *Pinus sylvestris* (Scots pine)

[3] FIDONIA PINARIA (phalena of the pine)—Dark brown moth; the upper wings

Henceforth submersion was not slow in finding numerous partisans. It has been practised a little all through France, and its use has extended to abroad. At the present time its efficacy is entirely accepted, and also the manner in which it is necessary to operate without injuring the submerged plants. In many districts the vines have been saved from complete destruction, and in other districts, formerly uncultivated, productive and flourishing vineyards have been created Carmargue is an example In this district, where, however, the inundation water is charged with salt, submersion presents special difficulties, and good outfalls must be organized if it is wished to avoid seeing the salt appear at great distances.

Submersion in Actual Practice.—To submerge certain privileged vineyards the water of a neighbouring river may be deflected in part and brought on to the land by a natural slope. In countries where water is scarce it has to be propelled on to the land by powerful centrifugal pumps working day and night In all cases of winter submersion the vineyard is divided into compartments of 4—6 hectares (10—15 acres), separated from each other by small dams and communicatory through small ditches Before running on the water, care must be taken that the surface is well levelled so that the water spreads regularly. In very windy districts Barral advises the vineyard being divided into more numerous compartments, the divisions between which serve to break the waves raised by the wind before they attain too great an amplitude. Duponchel, an advocate of underground irrigation, advises, in executing the latter, to excavate around each stock so as to lay bare the roots of the tree, thus forming as many closed basins which communicate with each other by small channels Water is made to flow therein and is imbibed to a great depth by the soil around the stocks When the ground is sufficiently wet and all the water has been absorbed, all that has to be done is to fill in the excavation with the dry soil placed on one side, to spread it and rake it. Submersion is performed either in winter or during the active period of the vegetation of the vine

A. Winter Submersion.—Winter submersion is a process which cannot evidently be applied everywhere, and which requires special conditions, of which the following are the principal · (1) The ground must be slightly permeable, or very permeable but with an impermeable subsoil, such as is met with in the low plains of the French coast, and in isolated spots in the river alluvial soils of some of the chief watercourses It is evident that too great a permeability of soil would require too large a volume of water The daily decrease in the level of the water should not exceed a maximum of 10 centimetres (4 inches), a centimetre in depth corresponding to 100 cubic metres of water per hectare, say 1404 cubic feet per acre. (2) The ground ought to be perceptibly flat or very slightly inclined, a slope of 3 centimetres per metre (3 in 100) rendering submersion impracticable. (3) The vineyard should be situated, if possible, near to a stream of water, to an abundant spring, or to an artesian well, for it requires at

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of the female are striped with yellow bands, 4 centimetres from tip to tip, the male 3 centimetres The caterpillars gnaw pine needles which they generally cut through the middle, letting one-half fall to the ground The ravages last from August to October.

least 6000 cubic metres of water per hectare, 84,780 cubic feet per acre. During the duration of the submersion, there is a daily loss of water, not only from absorption by the soil but also from evaporation into the atmosphere. The amount of water absorbed daily and the duration of the submersion have been studied by Chauzit and L. Tronchaud-Verdier, who have prepared the following table :—

TABLE II.—*Showing the Daily Loss of Water by Absorption by Various Soils during Submersion*

Soil	Duration of submersion		Daily loss of water.
	Autumn	Winter.	
Slightly permeable . .	50—55 days	55—60 days	1 centimetre
Fairly ,, . .	55—60 ,,	60—65 ,,	1 to 4 centimetres
Permeable . . .	65—70 ,,	70—75 ,,	4 to 7 ,,
Very permeable . .	90 ,,	90 ,,	8 to 9 ,,

Evaporation into the atmosphere averages 6 millimetres in twenty-four hours in winter, though it reaches 10 millimetres in summer. (That is at the rate of an output of 1 litre per second per hectare, which is calculated in general as the general output of the channels serving to irrigate meadows.) (4) The duration and efficiency of the submersion, moreover, depends on the climate. It is known that in France it can only be practised in the centre and south. In the north the vines would have to pass the winter surrounded by ice, which would seriously injure them. The duration of the submersion should average sixty days in south and thirty days in central France.

B. Submersion During the Active Period of the Vine.—Where large quantities of water are deficient, summer irrigations may be adopted. Debray has, in fact, remarked that the phylloxera is killed more easily during the active period of the vine, and that the duration of the submersion can be reduced to eight days in September, while fifteen to twenty days are required in October, and forty to sixty days in winter. In this connexion the underground irrigation described by Duponchel produces the best effect. So that submersion may be complete and efficacious, *i.e.* so that the water can penetrate 2 feet into the soil, it requires 1000—1200 cubic metres of water per hectare, say 250—300 litres (55—66 gallons) of water per stock. It is executed during dry periods, when vegetation is not very active. It has been found, on the other hand, that short, repeated irrigations lasting forty-eight hours in summer, especially if underground, are as injurious to the phylloxera as long winter irrigations. Whilst even three days' immersion in cold districts are injurious, underground irrigations of forty-eight hours in the dry regions of the South have a favourable action on the development of this plant. The causes, which in the exceptional conditions of the French climate insure the prosperity of the vine and the quality of French wines, are none other than the climate itself and the method of culture applied, the hoeing of the soil. It creates on the surface of the soil a shallow layer of friable earth, which by breaking the continuity of the capillaries arrests all evaporation from

below. The rain-water thus imprisoned in the soil without communication with the exterior air constitutes that lasting store of underground moisture, which can only be evaporated by the plant which aspirates it by the roots and which loses it by the leaves. The sap thus elaborated acquires that peculiar property of being specially apt to develop fruits, whilst in moist districts submerged too often the more aqueous sap perfectly produces herbaceous vegetation and yields few grapes. To produce grapes of superior quality the fruits must be developed in a warm medium, and the roots be in a moist and warm medium. These essential conditions are wanting when prolonged superficial submersion is practised, but are not greatly affected by the underground irrigations recommended by Duponchel. Superficial sprinkling of the soil never gives useful results as regards grapes, but develops branches full of leaves (*pampres*). The superficial evaporation of the water so sprinkled by cooling the soil must retard the ripening of the crop. Submersions would therefore in general be rather prejudicial to the quality of the crop of a healthy vine. As a curative agent, they produce, on the other hand, two effects equally advantageous, they enable the vine to reconstitute its radicular apparatus (root hairs) more or less atrophied by the gnawing of this pest From this point of view, the irrigation of the vines may be regarded as of practical utility, but it should be executed with the greatest of precaution so as to modify as little as possible the special conditions which insure the quality of the grape. A sufficient imbibition must be created to be injurious to the phylloxera, and favourable to the development of root filaments, avoiding all loss of heat by superficial evaporation. These conditions are realized by underground irrigation, especially if it be accompanied by the addition of nitrogenous manures. In spite of the good results obtained by submersion and underground irrigation, these can only be regarded as a palliative and not as a curative method. Long winter submersions, short summer irrigations, do not kill all the phylloxeras which ravage the roots, and a new invasion always occurs; thus the treatment should be annual. To diminish the number of the insects and stimulate the vegetative energy of the plant is not a sufficient remedy, and to re-establish the health of the plant it is well to destroy the parasites by powerful insecticides, such as carbon disulphide and sulphocarbonates, at the same time as the radicular system of the vine is strengthened by subterranean irrigations. Simple submersion along with strong manuring, by stimulating growth by moisture and fertilizers perceptibly diminishes the action of the phylloxera; but it only creates, in reality, a *modus vivendi* between the parasite and the plant. In these conditions the latter may produce abundant growth of leaf, but it will only give in the majority of cases a mediocre grape. It follows from the interesting researches of Maquenne and Dehérain, that when a soil is withdrawn from the action of oxygen, as happens when it is covered by a sheet of water, the nitrates which it contains disappear rapidly, owing to the action of certain reducing ferments. On the other hand, Muntz has tried to find out how the roots of vines immersed for two months can respire. This long privation of air ought to be injurious. To prove it, Dehérain and Vesque submitted vines for fifteen days to immersion in distilled water, and found

that they rapidly died, whilst others placed in aerated water were in perfect health. It is, therefore, the want of oxygen which in submersion may well prove fatal to vines, and that more readily when it is practised during the period of activity of the sap. River water used for submersion is the best, because it always contains air and nitrates, and vines submerged in these conditions resist for two months at least. That is an established fact which it is interesting to explain. The above-named scientific observers believe that the nitrates reduced by the ferments are converted into laughing gas, which contains oxygen, and may support the respiration of the roots This reduction observed in submerged land may become useful to vegetation, as it prevents the asphyxia of the vine It is thus necessary to spread on the land an appreciable amount of nitrate if it be desired that the submersion should not injure the vine. French vine growers use in fact 600 kilogrammes of nitrate per hectare (528 lb per acre), which is in no way exaggerated, but appreciably increases the cost of immersion Certain muddy waters, such as those of the Dordogne and Garonne, for example, enable the amount of the manure to be reduced a little However, in spite of all the care brought to bear on immersion, there are vines which do not support the treatment. Espitalier cites the following species which die very rapidly: La Carignac, le Grenache, le Mourvedre, la Clairette, le Malbec, le Merlot, and in general all the valuable species, whilst the Cabernet, the Petit Bouschet, and l'Aramon accommodate themselves well to it. This explains why simple immersion has been replaced in large vine-growing countries like the Gironde by irrigations with sulphocarbonate. Another drawback of submersion is that the vines planted in low grounds are attacked by all the cyptogamic parasites which multiply in moist districts and suffer more therefrom than anywhere else.

Moreover, the following, according to Tisserand, is the increase in the use of immersion and of insecticides in the treatment of the vine :—

TABLE III —*Showing the Increase in Area of the Submersion and Insecticidal Treatment of Vines in France.*

Year	Submersion	Carbon disulphide.	Potassium sulphocarbonate.
	Hectares	Hectares.	Hectares.[1]
1880	8,093	5,547	1472
1881	8,195	15,933	2809
1882	12,543	17,121	3033
1883	17,792	23,926	3097
1884	23,303	33,446	6286
1885	24,339	40,585	5227
1886	24,500	47,215	4459
1887			
1888	33,455	66,705	8089
1889	30,336	57,887	8841
1890	32,738	62,208	9377

[1] A hectare is $2\frac{1}{2}$ acres approximately.—TRANS.

To sum up, submersion, if of undeniable efficacy, is a primitive process, with many drawbacks, which should be advantageously replaced by irrigations with sulphocarbonate or with carbon disulphide. Amongst the antiphylloxeric treatments we should advise, according to circumstances, the following choice · Annual submersion may be applied where exceptional conditions combine, accompanying it, however, by very abundant manuring. Irrigations with sulphocarbonate and carbon disulphide are reserved for *de luxe* vineyards, such as those of Bordelais, Burgundy, and Champagne. Carbon disulphide, applied by means of the soil *injector*, is to be adopted preferably in small and medium cultures, and especially where the want of water renders submersion too costly

Spraying.—Spraying with cold water destroys the following parasites · *Capnodium* (*Fumagine*[1] or smut of fruit trees) —Sorauer recommends playing a jet of cold water on the crown of the trees after pruning that part. However, this operation must be repeated every evening in summer. *Capnodium salicinum*, Mntgn (hop black), may be prevented by spraying the leaves with cold water and repeating the process several days (Niajels). *Tingis pyri*,[2] Fb.—The pear tiger-beetle is fought against in the same way by spraying night and morning under the attacked leaves with cold water, or with a little soap added (Montillot) *Tetranychus telarius*,[3] L. ("red spider"), which forms on different plants a disease called "la Grise," is very sensitive to moisture and does not stand repeated cold-water spraying long (Thomas). *Bryobia ribis*[4] (gooseberry acarus) may be fought against by frequent sprinkling of the leaves Spraying with water can thus be used as a preventive against different species of Fumagine or smut (*Capnodium*), as a means of killing acari, of which the Tetranychus (red spider) is the most widespread and injurious.

(b) **Hot Water** acts very energetically on insects and fungi, which die in contact with boiling water Plants and their seeds generally stand heat better. That enables their parasites to be destroyed without injuring themselves.

Resistance of Insects to Heat.—All insects in seed are destroyed below 100° C (212° F). Bruchideæ (small weevils, pea-weevils) die

[1] FUMAGINE *Capnodium* (smut of fruit trees) —Fumagine is the term applied to the black coating which appears on certain plants infested by plant lice or coccides (scale insects) The damages caused by this fungus are serious because they injure the regular functions of the leaf, and they, moreover, soil the fruit which they render unfit for food The coccis and consequently the fumagine are very injurious to trees, especially in orchards.

[2] TINGIS PYRI *Tiger of the Pear-tree*—This brown flat hemiptera, 3 millimetres in length, appears in June Larvæ, grubs, and adults live as one family on the lower surface of the leaf or the young shoots, and riddle them with their pricks. The young shoots wither and the leaves brown

[3] TETRANYCHUS TELARIUS (red spider so-called) —A red, polyphagous acarus, it attacks the most diverse plants, chiefly trees, haricots, peas, clover, pumpkins, beets, hemp, hops, roses, limes, chestnuts, willows, and fruit trees. It produces the same symptoms on all these plants The leaves, prematurely discoloured, become copper yellow or red, and eventually wither, to fall before the end of summer The under surfaces of these leaves are covered with a very fine light tissue and white pellicles, in the midst of which the red acarus moves.

[4] ACARUS OF THE GOOSEBERRY. *Briobia ribis*.—Causes degeneration of the buds, leaves, and shoots, making them stunted and clustered.

in five minutes at 60° C (140° F) Ordinary weevils do not stand 50° C (122° F.) Grubs touched by water of 50—80° C (122—176° F) die without exception. Coleoptera (beetles) which sometimes stand great heat never bear 100° C. (212° F.) (Schribaux, Bussard, and Etienne).

Resistance of Seed to Heat.—Seeds can undergo a dry heat without injury, whilst the action of moist heat, and of water above 60° C. (140° F.) is often injurious. Seed-corn, with the exception of maize, can support a heat of 100° C. for an hour without its germination being affected. In spite of the considerable loss in water which the grain undergoes in such conditions, seed-wheat, for example, which contained 13 per cent. of water before being heated lost 9·4 of water during the operation Their vitality is not diminished Of Japhet seed-wheat heated for an hour in a stove at 105° C (221° F.) 97 per cent. still germinated; at 115° C. (239° F.) 95 per cent.; at 116° C. (240·8° F.) 93 per cent; at 120° C. (248° F.) 56 per cent.; at 125° C. (257° F.) 4 per cent. [Potatoes dipped in boiling water do not germinate.]

During researches on the *Alucite*[1] Doyere likewise succeeded in heating seed-wheat dried *in vacuo* to 100° C. (212° F) without it losing its faculty of germinating. By previously drying seeds at a low temperature Jodin heated grains of seed-wheat to high temperatures without alteration Peas and garden-cress seed heated directly to 98° C. (207° F.) for ten hours were no longer capable of germination, whilst others submitted to the same heat for the same time stood the heat perfectly, after being heated for twenty-four hours to 60° C. (140° F.). The peas retained a germinating capacity of 60 per cent. Therefore, if seed be heated in such a way as to allow the water to evaporate previously, by heating in an open vessel or in presence of such substances as sulphuric acid, calcium chloride, and quicklime, they undergo no alteration. Seed-peas under such conditions stood heating for 206 days at 40° C. (104° F).

Resistance of Fungi to Heat.—Fungi spores are generally remarkably sensitive to moist heat, but *per contra* they stand dry heat well. Schindler found that the spores of the *Ustilagineæ*[2] which resist very great

[1] ALUCITE. *Sitotraga cerealella*—Moth (tinea) of 6 millimetres in length, greyish-yellow, with long filiform antennæ. The female lays red eggs in the depression of the grain of wheat; before harvest the caterpillars penetrate into the interior of the grain stored in the granary where they finish their development; they gnaw the whole interior and only respect the epidermis After having emptied the inside of the grain they there weave a cocoon and are converted into chrysalides. The temperature of the heap of wheat attacked increases 10° C. (50° F).

[2] USTILAGO.—The mycelium of the *Ustilagineæ* lives in the interior of the plant; it gives rise to numerous fertile branches, inside which the spores are formed, which detached form a black powder These are the dormant spores. *Ustilago Maydis* (maize smut) may directly invade the young tissues of the adult plant None of the other *Ustilagineæ* can enter the nurse plant except at the birth of the latter. The mycelium which develops forthwith in the tissues of the seedling on the level of the ground, extends gradually into the whole plant without perceptibly affecting the growth of the latter It afterwards traverses the whole nurse plant, and whilst life is gradually extinguished in the lower parts of the plant it concentrates itself towards the top and arrives at maturity in the ears at the end of the period of growth of the plant. The spores of *Tilletia* are enclosed at harvest time in the interior of the rusted grain and are almost all carried to the granary where they are spread over the corn during threshing.

dry heats, are rapidly injured if the hot medium is saturated with water vapour In these conditions the spores of black rust perish at 60° C. (140° F.), those of brown rust at 45—50° C (113—122° F). Herzberg has compared the resistance of spores of different ages to the action of heat, and found the following temperatures as those at which they succumbed —

TABLE IV.—*Showing the Temperatures at which the Spores of different Species of Ustilago are Killed*

	U Jensenii	U Avenæ	U Perennans	U Hordei.	U. Tritici
	°C	°C	°C.	°C.	°C.[1]
Old spores .	47—50½	45½—47½	40½—42	43½—45	46 —47½
Young spores	50—53	50½—53½	47½—50½	45½—47¾	45¼—47¾

It follows that the young spores are more resistant than the old ones, and that the temperature required to destroy the vitality of a spore is not the same for spores of different species.

Use.—The sensitiveness of parasites to hot water and the comparative resistance of plants have permitted the use of different treatments, especially preventive, to free plants from certain diseases.

Immersion or Steeping.—This consists in dipping seeds or plants in hot water to free them from disease germs adhering to their surface.

Hot Water Steeping of Seed-corn to Kill Disease Spores—Steeping seed-corn in hot water is practised before sowing to destroy the dormant spores of smut and bunt, which adhere to their surface and help to propagate these diseases. Brefeld, observing that cold water was injurious to the development of the spores of bunt, tried washing seed with cold water, and so obtained an appreciable but incomplete result. On the other hand, hot water has been recognized as deadly to the spores of these fungi, and treating the seed by hot water would wholly suppress cryptogamic diseases if the seed formed the sole factor of their propagation. To get satisfactory results steeping the seeds in hot water should be done in a strictly scientific manner. It is only efficacious if the temperature of the bath has been rigorously maintained at a certain degree A greater heat than that required to kill the spores should be avoided, for it will appreciably diminish the germinative capacity of the seed, and may even destroy it. If there be a difference of sensitiveness between the seeds and the spores as regards heat, it is so small that a difference of a few degrees may be fatal. A low temperature should also be avoided, as it favours the disease instead of preventing it. Warm moisture helps, in fact, a premature development of the spores. The promycelium and the sporidia formed then attack the young plant as soon as hatched. It is a known fact that bunt as well as smut are more injurious to the plant the younger they attack it. When well done, steeping in hot water imparts to the seed in many cases a greater germinative capacity, so that the plant has acquired a certain development when the spores which have escaped

[1] To bring to Fahrenheit, multiply by 9, divide by 5, and add 32.

the treatment germinate. That is one reason in favour of steeping; the other methods of treating seed generally retard their germination. Steeping gave in certain cases results which it had been impossible to obtain by sulphating (Kuhn's), and it is in such particular cases that its use is prescribed, in spite of the difficulties of carrying it out which the farmer has to face in a peculiarly complicated plant, and the minute practical care required to secure a good result. B. Prevost was the first to observe that steeping seed-corn in hot water diminished the power of contagion of smut Jensen studied this treatment with great care and perseverance, and other investigators confirmed Jensen's very precise observations and conclusions. The following, according to Eriksson, is the manner in which Jensen's method should be applied on the large scale. The operation requires (1) A boiler or large pot in which to boil water. (2) Three tubs No. 1 for hot water, No 2 for tepid water, No 3 for cold water (3) Two willow baskets, completely lined inside, including the lid, with bolting cloth. (4) A thermometer. After having prepared a certain amount of boiling water, 50 litres (11 gallons) are withdrawn and run into the first tub, which is cooled to the desired temperature with 40—50 litres (9—11 gallons) of cold water. In the second tub about 20 litres (4·4 gallons) of boiling water are mixed with 80 litres (17 6 gallons) of cold water so as to get a temperature between 25° and 30° C. (57—86° F.). Cold water is run into the third tub. The seed to be treated is placed in baskets, the lids of which are carefully closed so as to enable them to be completely immersed. Each basket contains about half a bushel of seed. After firmly attaching the basket to a stick it is plunged, first in the cold water to moisten the grain completely, then the same operation is repeated in the tepid water, taking care to raise up the basket and re-dip it several times. Finally it is dipped for five minutes in the hot water, raising and lowering the basket. The operation is finished, and the grains so treated can be immediately sown by hand, or they may well be spread out to dry. It goes without saying that it is necessary to disinfect the boards on which the grain is spread perfectly, as well as the bags to contain it, by hot water, Bordeaux bouillie, or simply a solution of sulphate of iron. With three men and two baskets 400—500 litres (11—13¾ bushels) of grain may be disinfected in an hour. Kellermann and Swingle have simplified this process by dispensing with one of the three tubs, the cold water one. They only use a tub of water at 43—54° C. (109·4—129·2° F.) and a tub of water at 56° C. (132·8° F.). They use a basket of wire gauze of a capacity of 36 litres, say 8 gallons, which they only half fill with grain, or simply a canvas bag They first dip the basket for a minute in tepid water to warm the grain, then fifteen minutes in hot water at 56° C. They consider it useless alternately to raise and lower the basket into hot water. Each cereal is attacked by one or several species of rust, and it is necessary to examine the action of Jensen's treatment on each of its parasitics, *Ustilago Hordei*, Bref., on barley (*Hordeum vulgare*) and *Ustilago Jensenii*, Rost., on barley (*Hordeum distichum*). The steeping of grains of barley exhibits certain difficulties when these are still surrounded with glumes. By ordinary steeping, the spores between the grains and the glumes are not killed even if the water is raised to 60° C. (140° F.), whilst in an

atmosphere containing the vapour of water, Jensen has observed destruction to be complete at 52½° C. (126½° F) Eriksson got excellent results by softening them for hours in cold water before steeping, and allowing them to swell for four hours in an aerated place, afterwards bagging them up. It suffices, therefore, to immerse the grain for five minutes at 52·5° C (126½° F., Jensen), at which heat all the spores perish. The water can, without fear of diminishing the germinative capacity of the seed, be heated up to 60° C (140° F), barley standing that heat without injury. According to Kuhn, it is injurious to leave the grain for twelve hours in cold water before proceeding to the (hot) steep, but by not exceeding four hours Sorauer found that such was in no way injurious to the development of the seeds. Kellermann, Swingle, and Kirchner dispense entirely with the first immersion in cold water, and claim to have obtained satisfactory results by one dip in hot water at 52·5° C. (126½° F.), even if the grains be glumed. Kirchner found that after a dip of five minutes in water of 56° C (132·8° F.) grains of seed-barley germinated thus .—

TABLE V.—*Showing Effect of Steeping Seed-barley in Hot Water on Germinative Capacity.*

	Germinated after two days Per cent	Germinated after ten days. Per cent
Treated	74·5	98 0
Untreated	69 75	97 0

Besides the disinfectant action there is thus an evident increase in the germinative capacity of the seeds.

Ustilago Tritici, Jensen (smut of wheat, *Triticum sativum*), *Tilletia caries*, Tul., "stinking smut" or "bunt" of wheat, *Tilletia levis*, Kuhn (loose or flying smut of wheat).—According to Herzberg, the spores of *Ustilago Tritici* are destroyed at a temperature of 48° C. (118·4° F.), and those of *Tilletia* do not germinate after immersion in water of 55—56° C (131—132·8° F). By treating wheat grain by one immersion of five to fifteen minutes in water of 56° C. (132·8° F.), Sorauer obtained the following results —

TABLE VI.—*Result of Steeping Seed-wheat in Hot Water during different Periods of Time*

Untreated grain .	87 per cent of plants which gave 5 17 per cent of "bunted" ears.
Grain treated five minutes	91 per cent of plants which gave 0 225 per cent. of "bunted" ears.
,, ten minutes	87¾ per cent of plants which gave 0·157 per cent of "bunted" ears.
,, fifteen minutes	87¾ per cent. of plants which gave 0·071 per cent of "bunted" ears

By treating the grain with 0 5 per cent of blue vitriol he obtained 86⅓ per cent of plants. It may therefore be inferred that an immersion of five minutes suffices, and that it has an advantage over blue vitriol because it stimulates germination instead of retarding it like the latter. Klebahn, however, is of opinion that immersion has no advantage over vitriol steeping, and Kirchner asserts that it diminishes the germinative

power. Selby found that the same result was got by immersion as by treatment for twenty-four hours with a solution of 0 5 per cent of blue vitriol, 0·2 per cent. of formalin, and 0 75 per cent. of potassium sulphide When wheat is immersed on the large scale against bunt it is well to dip the grain first in water, skim it, and cast aside all those grains which float. These are precisely the bunt-infested ones. Those which lie on the bottom of the water are alone dipped in the hot water. *Ustilago Avenæ*, Rost (loose smuts of oats, *Avena sativa*); *Ustilago perennans*, Rost (smuts of oats, *Avena elatior*).—The spores of *Ustilago Avenæ* stand air heated to 52° C (125·6° F.), but they do not stand dipping in hot water at 54—56° C (129·2—132·8° F) (Sorauer). Kirchner found that seed-oats treated in that way gave the following results against untreated :—

TABLE VII —*Showing Effect of Steeping Seed-oats in Hot Water on Germinative Capacity*

	Germinated in two days. Per cent.	Germinated in ten days. Per cent
Treated . . .	24·75	84·5
Untreated . . .	6·75	81·75

Treatment on the large scale lowers the percentage of diseased plants to about 0·2—0·7 per cent (Eriksson). According to Kellermann and Swingle, a fifteen minutes' dip in water at 55·6° C. does not alter the germinative power of oats, and all authors agree in saying that the immersion of seed-oats is better than treatment with blue vitriol, because it stimulates instead of retards the germination It is therefore from this point of view a useful discovery, and Klebahn is of opinion that this treatment, general for all other cereals, is prescribed for oats.

Urocystes occulta, Rabenh. (smut of the stems of rye) —By immersing seed-rye for five minutes in hot water Kirchner obtained against untreated grain the following results :—

TABLE VIII.—*Showing Effect of Steeping Seed-rye in Hot Water on Germinative Capacity.*

	Germinated in two days. Per cent.	Germinated in ten days. Per cent.
Treated	91	95 5
Untreated	95 25	98 0

Trials on a large scale by Klebahn did not give better results. The immersion of seed-rye presents no advantage in this case over treatment with blue vitriol, because it retards germination like the latter.

Ustilago Panici-Miliacei,[1] Wint. (smut of millet).—Treatment with blue vitriol or immersion may be employed indifferently, as they both give the same results. The millet seeds must be left seven and a half to twelve minutes in water at 55° C. (131° F.).

[1] USTILAGO PANICI-MILIACEI (smut of millet).—This invades all the parts of the flower of millet and damages them. The spores are formed in the inflorescences when they are yet enveloped in the sheath of the top leaf.

Ustilago Maydis,[1] Corda (smut of maize).—Nijpels prescribes the immersion of maize by Jensen's method, it gives good results

Ustilago bromivora, Fisch. (smut of brome grass, *Bromus arvensis*).—According to Rostrup immersion has also been tried with success against this disease.

Sphærella Tulasnei, Junez (black of cereals, *Cladosporium herbarium*).—Giltay prevented the development of this disease by immersion in hot water. Kolpin Kavn prevented it entirely on barley and oats by Jensen's immersion at 52—53° C (125·6—127·4° F) for five minutes, after previously softening the grain for fifteen minutes in cold water.

Puccinia [2] (rust of cereals).—The numerous experiments of Galloway in America to diminish the rust of cereals by dipping the seed for fifteen minutes into water heated to 56° C (132·8° F) have not given the result anticipated The treated seed gave as many diseased plants as the untreated. That is due to the method of development of the fungus, which does not appear, in fact, to propagate itself through the seed. Immersion has also been used to prevent beet diseases, due to fungi propagated through the seed. These diseases are *Pythium de Baryanum*, Hesse, *Rhizoctinia violacea* [3] Tul. (beet Rhizoctone); *Phoma tabifica*, Pril. et Del. (disease of the petioles of the leaves); *Pleospora putrefaciens*, Frank. (rottenness of the heart). Jensen's method has given excellent results, and it follows from the trials made by Hollrung that immersion, instead of injuring the seed, on the contrary stimulates their germination. Treatment with cold water greatly increases the germinative capacity of beet seed; but it must not be kept ninety days after immersion before sowing, because the effect gradually disappears. If the seed be sown soon after immersion an excellent result is obtained with very few diseased plants. The procedure is as follows . The seed, in a wire-gauze basket, is immersed for six hours in cold water, left to drain ten

[1] USTILAGO MAYDIS (smut of maize).—This smut attacks the fructified maize, not only in the floral bracts where it forms large, unshapely smutty tumours on the panicles of the male flowers, but also on the stems themselves where the amassed spores form bulky excrescences.

[2] *Puccinia*. RUST OF CEREALS —At least three different species of rust are to be seen on grain crops They are uredinæ which are termed heteroic because during their cycle of evolution they must live on nurse plants of different orders The uredinæ are parasitic fungi the mycelium of which grows exclusively in the interior of the body of green plants Their spores are generally formed under the epidermis of the nurse plant, whence it spreads outwards through the tearing of the epidermis which occurs. It is from the orange-brown colour of their spores that the uredinæ are termed *rusts*. The leaves charged with rust spots are soon exhausted, they turn yellow and die prematurely.

Puccinia graminis.—This rust attacks wheat, barley, oats, a host of common grasses, such as meadow grass, couch grass, dactyla, agrostis, foxtails, festuca, etc. It is the most dangerous rust of cereals. It particularly attacks the leaves, their sheaths, and the stalks (straw).

Puccinia coronata.—This rust is peculiar to oats. It has the uredo and puccinia forms on oats, but the æcidium form on different plants of the *Rhamnaceæ*, particularly buck-thorn and black alder.

[3] *Rhizoctinia*.—Parasitic fungi which develop on plant roots, penetrate into their interior, and kill them Their vegetative system is highly developed and enables them to pass in the soil from one root to another Sclerotes, sorts of tubers, enable them to live a latent life when outside conditions are unfavourable to their development.

to twelve hours in an airy place, then dipped for five minutes into water heated to 53 5° C (128·3° F.), taking care to dip and raise the basket at regular intervals Nothing further is required but to pass the seed into a bath of cold water, and it may be sown at once, or after standing for not more than ninety days Summing up, Jensen's method sometimes gives results inferior to treatment by blue vitriol, because it scarcely ever diminishes the germinative capacity of the seed treated; it is only really prescribed for the disinfection of seed-oats, for the results are undoubtedly superior. For all other cereals blue vitriol, Bordeaux bouillie, or potassium sulphide may be prescribed The latter process was recommended by Jensen himself in 1895 ("Ceres" powder) as capable of replacing immersion

Immersion of Seed against Insects.—*Phylloxera.*— Balbiani's researches on resistance of phylloxera eggs show that non-rooted buds can be treated preventively by one dip of five to ten minutes in water heated to 45—50° C Experiments renewed in 1887 by G. Couanon, G Henneguy, and E Salomon confirm the results obtained. This method is currently used to-day. Not only does it cause no prejudice to slips catching root, but it seems, on the contrary, to facilitate it And the importance of this treatment is so much the greater as it follows from determinations made in Algeria (1885), in Champagne (1890) and in Lorraine (1894), that new phylloxera hot-beds have no other origin than plants coming from countries infested with this formidable insect. G. Couanon and J Michon resumed the same experiments and extended them to rooted plants which are most frequently used in the reconstitution of vineyards. Rooted Noah plants, dipped for three, four, and five minutes in water at 53° C. (127·4° F) (51° C. at the exit, 123 8° F.), were planted at the same time as test samples. They took root completely, as well in the greenhouse as in the open air, and the vines grew very finely. Dipping in water at 53° C. (127·4° F) is thus a practical and economic method for disinfecting vines, rooted or not, for it kills at the same time both the insects and their eggs. It has also the advantage over the sulphocarbonate treatment recommended by Mouillefert, that it does not require, like this latter, two to three hours, and has no injurious action on the plants (Balbiani). Disinfection by hot water gives very satisfactory results; the same process has been used for other fruit trees intended for sale, and coccides, the woolly aphis,[1] and other injurious insects, have been simultaneously destroyed According to Danesi, all fruit trees, the peach excepted, stand very well being dipped for five to ten minutes into water at 53° C. (127·4° F). To ensure complete disinfection the whole plants must be entirely dipped into the water at 53° C. (127·4° F), and dried in the air on a copper grating. They can then be packed in disinfected moss and despatched.

Bruchus Pisi, L (pea-weevil) —To kill this insect Fletcher recommends the following method: A vessel is taken which is half-filled with the infested peas, and boiling water poured on until they are

[1] Woolly Aphis. *Schizoneura lanigera* (also known as *Eriosoma lanigerum*).—This aphis, like the phylloxera, lives as well on the roots as on the aerial part of the plant, but it prefers the branches to the roots. It especially attacks the apple-tree The diseased condition of the trees is known by their perishing, and their leaves which rapidly turn yellow and fall during summer.

entirely submerged The vesssel is then filled with cold water and left to stand for twenty-four hours The peas which do not suffer from the treatment and which are entirely freed from the insects they sheltered can then be sown De la Bonnefon advises dropping the peas into water and leaving them there for some hours. The peas which remain at the bottom are put into an oven the temperature of which is 60° C. (140° F.). After some time they are taken out and then sown.

Hot Water Spraying.—Spraying plants with hot water has not only been used to destroy injurious insects, but also to cause certain fungi to disappear, such as the *Erysipheæ* [1] or mildews, which crawl on the surface of the epidermis without ever penetrating into the interior of the tissues. It is owing to this peculiarity that they can be destroyed by hot water. The leaves of plants stand without injury sprayings of 77—85° C. (170·6—185° F), whilst at that temperature the mildews disappear entirely. The roots alone of the plant must be protected, because they suffer from contact with water at that temperature. Hot spraying has been used against the following mildews: *Uncinula americana* [2] How. (oidium of the vine); *Sphærotheca pannosa*, Lev. (mildew of the rose bush), *Sphærotheca Castagnei*, Lev. (mildew of the hop).

Hot Water Treatment of Soil against Woodlice.—Where apparatus is available for the distribution of water at a high temperature in glass-houses, the treatment is undoubtedly the most radical in the control of woodlice. To determine the effect of temperature on these woodlice, a thermostatic bath was employed. In this was placed a vessel containing soil into which the woodlice could be introduced. With the water in the thermostat at 147° F., the soil at an internal temperature of 146° F., and with a surface temperature of 124° F., all woodlice introduced on the soil surface were killed in 30 seconds. With the thermostat temperature at 140° F, the soil internally at 136° F., and the soil surface at 108° F, woodlice similarly introduced were killed within two minutes. Woodlice dipped for half a second in water at 149° F, died within a few minutes after immersion. These experiments show that the *Armadillidium vulgare* is easily killed by water at comparatively low temperatures and accounts for the efficiency of the hot-water treatment

Hot water has found numerous applications against insects very sensitive to heat. *Galeruca* [3] of the elm, *Formica*, ants, *Pierides* [4]

[1] Erysipheæ. *Mildews.*—Mildews form on the leaves and on the young parts of the plants powderish, whitish spots. The mycelium of the mildew is always superficial, it crawls on the surface of the epidermis without penetrating into the interior of the organs It sinks its suckers in the epidermis.

[2] Oidium of the Vine. *Uncinula americana, Oidium Tuckeri*—The mycelium of this fungus lives on the surface of the plant and draws its nourishment from the cells of the epidermis by numerous suckers. The organs attacked are rapidly altered, the extremities of the young shoots wither, the leaves shrivel up and die, but the effect is still more deadly on the grapes, which crack and rot.

[3] Galeruca of the Elm. *Galeruca clamariensis*—The larva of this insect is as injurious as the perfect insect. The eggs laid on the leaves hatch in May; the larvæ, very voracious, reduce the leaves to skeletons up to the time they nymphose The parenchyma of the leaves being gnawed the veins alone persist, and the leaves, reduced to a skeleton, soon fall

[4] Pieris brassicæ *Pieris rapæ* (large white cabbage butterfly, small white cabbage butterfly).—They are white, diurnal, well-known butterflies. The former

of the cabbage, *Cochylis pyralis* of the vine, Cabbage lice, *Diaspines*, coccides, red spider.

Galeruca calmariensis (*Galeruca* of the elm).—To destroy this insect, Robert sprays the stock and the lower part of the trees with boiling water The time selected for doing so is when the larvæ are being transformed into grubs around the stock, *i e* about the end of July or beginning of August

Formica (ants).—Boiling water destroys ants. It may be used whenever there is no risk of touching the roots, which do not stand hot water at that temperature.

Pieris (*Pierides* of the cabbage)—When they are not destroyed when they are small, the grubs of *Pierides* (white butterflies) so ravage cabbage as to render them unsaleable. Riley has observed that the grubs die when they are sprayed with water at 55° C. (131° F.), whilst cabbage leaves do not suffer at that temperature.

Cochylis ambignella, Hubn (*Cochylis* of vine), *Tortryx vitana* (*Pyralis* of vine).—Scalding is the best method of destroying these insects. It consists in spraying the stocks with boiling water when vegetation is arrested, and when the insects have chosen the fissures in the bark as a common refuge. Raclet having found all the advantages of scalding, advised its use, preferably in March or April According to the researches published by Terrell des Chênes, it has been definitely decided: (1) That scalding, even when applied ten years running, did no harm. (2) That it not only destroys *Pyralis*, but also many other insects of the vine (3) That it also destroys the vegetable parasites of the vine, mosses, lichens, etc (4) That it stops the growth of adventitious buds along the old wood which is a loss of sap for the stock and thus saves pruning However, in spite of the excellent results, this method is practised very little, and that because it requires a litre of boiling water per stock, and it is not easy to use such large quantities in the middle of a field. For some years scalding of vines has become common by an improvement in the apparatus. The water is now heated in a portable boiler fitted with two lugs by which it can easily be carried. When the water boils the workman is warned by a whistle on the safety valve. He then fills a sort of tinned-iron coffee-pot holding a litre, and covered with cloth, or better still with a double jacket, so as to prevent cooling. The water must be at 80° C. (176° F.) at the time it touches the stock for the destruction of *Pyralis*, and 90—100° C. (194—212° F) for *Cochylis*, so that it may penetrate the silky cocoons which protect the small grubs. To increase the temperature of the water carbonate of soda may be added; 5 or 6° C. (9—10·8° F.) extra are thus obtained which make up for the exterior cooling. In emptying the coffee-pot entirely on each stock the workman must act rapidly. He should with the drawn-out spout of the coffee-pot pour the hot water on the stock, rising in a spiral from the bottom, so that the water at the required temperature penetrates into all the interstices of the bark. The operation must be performed from below upwards, for if scalding was begun from the top of the stock the excess of water, perforce

female lays its eggs in June on the surface of the cabbage leaves where these masses form plates of a white colour; the female of the second lays its separate eggs in packets.

cooled, would flow over the lower parts and fill the interstices; the boiling water poured afterwards would have no mortal effect on the insects on the bottom of the stock, because they would not receive it directly. This precaution is particularly necessary in treating old vines, because these are generally the refuge preferred by grubs owing to the roughness of the stock Two workmen suffice to carry out the scalding, one feeds the fire and fills the boiler as the boiling water is drawn off, the other runs the hot water into the coffee-pots and pours their contents on the stocks Working thus, 1500—2000 stocks can be treated per day. The boiler consumes about 200 kilogrammes (4 cwt) of coal per day. To diminish the labour, large boilers are also used, with taps to which india-rubber tubing is attached ending in a nozzle, with intermittent jet. This nozzle which projects the water on the stock has the advantage of penetrating deeply into the cracks of the bark. This process, though preferable to others, is only used

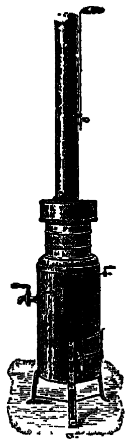

FIG. 3.—Portable Boiler

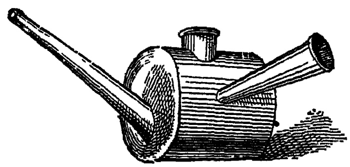

FIG. 4 —Coffee-Pot for Scalding Vines with Hot Water.

in large vineyards. Scalding should be done after the vintage when the grubs have taken refuge in the bark, and before they have assumed the chrysalis form, for the latter is not so sensitive as the grub. It is carried out as soon as pruning is finished and preferably in calm, fine weather. To combat the *Cochylis* it is necessary to operate in October or November, whilst the grub has not yet finished its cocoon; against the *Pyralis*, which remains all winter as a grub, proceedings can be taken all winter up to May before escape from the cocoon. In districts where props are used these are boiled by placing them in cases, into which steam is injected for eight to ten minutes, or by steeping them in boiling water for five minutes. Scalding carefully done with water at the temperature indicated is always efficacious, and has no injurious action on the vines if care be taken to perform it before the appearance of the bud. It is recognised that of all the treatments adopted against the *Pyralis*, scalding is still that which succeeds best. But it must be carried out with a certain regularity each year, otherwise the butterfly

would again appear. This is the treatment which succeeds best against the *Cochylis*, provided it be done from October to November.

Margantia histrionica, Hahn (the red cabbage bug) —Murfeld has shown that these small bugs do not stand water heated to 65·5° C (150° F), a heat which does not alter cabbage leaves Coccides [1] also suffer much from treatment with hot water Reh found that generally they did not stand a great heat. Water at 54° C. (129·2° F) kills them in forty minutes and water at 55° C. (131° F) in twenty-two minutes; water at 60—65° C. (140—149° F) kills the apple coccis, *Aspidiotus ostreaformis*, and the pear coccis, *Diaspis piricola*, but most coccides stand a greater heat. The scalding of trees in winter is, therefore, an excellent method of freeing them from all these parasites.

Tetranychus telarius, L. (red spider).—In November this acarus takes refuge under the bark of the stock. The hot-water treatment can then be applied. The scalding executed as described above to destroy *Pyralis* can at the same time get rid of the red spider.

Hydrogen Peroxide, H_2O_2.—Preparation.—By decomposing barium peroxide by hydrochloric acid in the cold and then precipitating the baryta by sulphuric acid.

BaO_2	+	$2HCl$	=	$BaCl_2$	+	H_2O_2.
Barium peroxide		Hydro-chloric acid.		Barium chloride.		Hydrogen peroxide.

Properties.—Hydrogen peroxide is a colourless syrupy liquid. A heat of 27—30° C. (80 6—86° F.) and light decompose it into water and oxygen. Aqueous solutions are very unstable but a small amount of sulphuric acid gives them stability

Use.—The numerous applications of hydrogen peroxide in human

[1] COCCIDES OR COCHINEALS (plant lice, bark lice, scale insects, kermes) —These homoptera much resemble the "pucerons" by their manner of living. After hatching, these insects show great agility, then the apterous females fix themselves either on the young shoots, the leaves, or the trunks, sink their rostrum in the tissues and never move again The body is ovoid, globular, and resembles a small excrescence of the bark. The female lays its eggs under this shell and dies, forming with its carapace a protecting shelter for its progeny The most common are the following —*Coccus of the Apple* (*Mussel scale*) (*Mytilaspis pomorum*), (? *Aspidiotus conchiliform*).—The shield resembles a small mussel shell. It attacks apple trees. *Coccus of the Peach* (*Lecanium Persicæ*) —Very frequent on peaches in May and June *Coccus of the Pear-Tree* (*Aspidiotus ostreaformis*) (the pear-tree oyster scale) —One of the most common, distributed on the branches of fruit trees, especially apple-trees, where it forms small greyish spots *Coccus of the Pear-Tree* (*Diaspis piricola*).—Analogue of the coccus of the apple-tree; the coccus of the pear-tree has a red colour and not yellow like that of the apple-tree, a colour which is discerned by lifting the shield with the blade of a knife. *Coccus of San José* (San José louse) (*Aspidiotus perniciosus*).—It much resembles the preceding, and exercises its ravages, especially in America, on both fruit and forest trees. *Coccus, White, of the Lemon-Tree and Orange-Tree* (*Dactylopius citri*).—Its brown body is enveloped in a white waxy secretion; the trees attacked look as if covered with cotton. *Coccus, Red, of the Vine* (*Coccus Vitus or Pulvinaria Vitus*) —The red coccus of the vine has the appearance of a reddish-brown shell, at the time of laying, it secretes a whitish cottony substance which forms above the body a sort of cushion very apparent. *Coccus, White, of the Vine* (*Dactylopius Vitus*).—The white coccus of the vine, contrary to the red coccus of the vine, never fixes itself and lays its eggs several times.

medicine led to the expectation of good results in the treatment of plant diseases with this product. Hitchcock and Carleton tried hydrogen peroxide in solution of different strengths on the uredospores of *Puccinia*, but a solution of—

TABLE IX.—*Result of Treating Puccinia Uredospores with Hydrogen Peroxide of Various Strengths*

0 1 per cent	acting during	7 hours	on spores of	*Puccinia graminis*, Pers
1 0 "	"	"	17 "	"	*Puccinia Rubigo vera*,[1] Wint
3·0 "	"	"	14 "	"	*Puccinia coronata*, Corda

far from destroying these spores rather favoured their development than otherwise.

[1] *Puccinia Rubigo vera* (Rust, Spotted).—The uredo pustules formed on the leaves and the stems of cereals are more oval than those of the linear species It is *the* rust of *wheat*, although it also attacks *rye* and *barley*

CHAPTER II

HYDROGEN SULPHIDE—SULPHUR

Hydrogen Sulphide (Sulphuretted Hydrogen, H_2S).—**Preparation.**—By decomposing sulphides by a dilute acid. Iron sulphide is generally used. It is dropped in pieces into a Wolff's flask, two-thirds filled with water. By running in dilute sulphuric acid through a funnel there are produced (1) iron sulphate and (2) sulphuretted hydrogen, which is collected in a gasometer

Properties.—Hydrogen sulphide is a colourless gas with the odour and taste of rotten eggs It burns with a blue flame. It is very poisonous and treacherous, for it acts without any other warning than a bad smell. A small bird perished in an atmosphere which contained $\frac{1}{1500}$th; a horse does not live long in an atmosphere containing $\frac{1}{200}$th of this gas. Under its influence the globules of blood are unable to fix oxygen.

Action on Plants.—Hydrogen sulphide is also injurious to plants; in its presence the leaves are coloured with yellow spots, which entirely invade them, then the plants die. Schroder and Reins found that to be the case in the neighbourhood of factories which disengage a certain amount through their chimneys; gasworks amongst others, for coal gas always contains a certain quantity. An atmosphere only containing $\frac{1}{3000}$th of hydrogen sulphide, that is to say, an amount scarcely perceptible to the smell, but slightly blackening paper steeped in lead acetate, is poisonous to the plant. However, the toxic dose varies greatly with the species of plants. Even roots themselves are capable of absorbing it, and take a blue colour (Kny).

Action on Insects.—Mouillefert has examined the action of hydrogen sulphide on the phylloxera. On roots exposed in a flask filled with this gas these parasites died in three minutes, but whilst at the end of that time the adults were dead, the larvæ and the eggs did not appear to suffer In an atmosphere containing 1 volume of H_2S in 100 volumes of air the phylloxeras were found dead after twenty-four hours. If it contained 1 volume of H_2S in 150 volumes of air it took forty-eight hours to destroy these lice completely. Now, as a litre of sulphuretted hydrogen weighs 1 5 grammes, an atmosphere containing 1 per cent. of this gas by volume only contains by weight 0·0015 per cent. of that acid. As that amount represents the limit of toxicity of this gas for the phylloxera, and as it requires 0 0016 gramme of carbon disulphide in 100 c.c. of air, it may be concluded that hydrogen sulphide is as poisonous to insects as carbon disulphide.

Use.—*Phylloxera.*—To utilize this property, therefore, of hydrogen sulphide, it only remains to discover a process capable of giving rise

to the formation of this gas in the layers of soil round an infected vine. The alkaline sulphocarbonates fulfil this object. They decompose in the presence of moisture and acidity of the soil into alkaline carbonate and hydrogen sulphide

$$K_2CS_3 + H_2O + CO_2 = K_2CO_3 + CS_2 + H_2S$$

K_2CS_3	H_2O	CO_2	K_2CO_3	CS_2	H_2S
Potassium sulpho-carbonate.	Water	Carbonic acid.	Potassium carbonate	Carbon disul-phide.	Hydrogen sulphide.

Mouillefert tried ammonium sulphide, which acts perceptibly on the phylloxera in the same way as hydrogen sulphide. He buried around the roots, after having laid them bare, 500 grammes (1$\frac{1}{10}$lb.) per stock of a mixture of 36 parts of calcium sulphide and 66 parts of sulphate of ammonia Under the influence of moisture these two salts dissolve in the ground, and yield by double decomposition ammonium sulphide and calcium sulphate The result was negative

Melolontha vulgaris (cockchafer)—The insecticide property of hydrogen sulphide has been utilized to destroy numerous injurious insects, living in the soil, especially the *white worm*. Dr. Precht has taken out a German patent to claim a process of formation of this gas in the soil. Prior thereto Roy had recommended the burying in the ground of cinders rich in iron sulphide. In Italy good results are obtained against the white worm by ploughing in white mustard, more especially mixed with one ton of gypsum per acre. The decomposition of these plants would appear to produce much sulphuretted hydrogen

Heterodera Schachtii, Schm.—The ploughing in of crucifers and gypsum did not give the result expected.

Coccides.—Coquillet did not succeed in destroying the *coccus* of the lemon by covering this tree with an awning, and disengaging sulphuretted hydrogen under this improvised "cloche." [1]

Sulphur, S—Sulphur, in combination with metals and metalloids, is very widely distributed in nature. It is chiefly met with as sulphides of iron, copper, lead, mercury, zinc, antimony, and arsenic. Native it is found in lacustrine deposits associated with marl, and especially in the precincts of volcanoes as a product derived from volcanic emanations. It is found in the mines of Vesuvius, of Lateria, near Rome, in those of Etna and Stromboli, beneath the marshes of Texas, Lousiana, and in other States of the U.S.A.

Preparation.—For agricultural purposes sulphur is prepared under different forms: (1) *Sublimed sulphur*, or *Flowers* of sulphur, is an extremely fine powder of a yellow straw colour, which, examined under the microscope, appears as small rounded grains, studded with small points. It often contains sulphurous acid and sulphuric acid in the proportion of 1 per cent. (2) *Ground sulphur* is obtained by the pulverization, grinding, and sifting of brimstone. Ground sulphur can

[1] *Note by Translator*.—But it must not be forgotten that sulphuretted hydrogen is heavier than atmospheric air in the proportion of 37 to 31, that is, 100 cubic inches of the former weigh 37 grains, and of the latter 31 grains This difference in density must retard diffusion, so that the bottom of the plant would get an undue share and the top less than its share. Instead therefore of placing the generating vessel on the ground it should be at least well up the tree.

now be obtained the fineness of which almost equals flowers of sulphur. It has the advantage of being neutral and cheaper. It consists of angular grains, and is paler than sublimed sulphur. (3) *Wind-blown sulphur* is of a bright colour, absolutely neutral, and can be passed through a 100 sieve, which proves that it is almost as fine as precipitated sulphur. It shows branching particles under the microscope and grains of regular dimensions. Like ground sulphur, it neither contains sulphurous nor sulphuric acid. It is dearer than ground sulphur (4) *Precipitated sulphur* is impalpable. It is extracted from the spent material used for gas purification, when it is imperfectly purified it still contains tar, cyanides, and, as it is somewhat hygrometric, it burns the leaves. Hence its restricted use in the sulphuring of plants. It is obtained, also, by a chemical method alkaline polysulphides, treated by hydrochloric acid in aqueous solution, give off hydrogen sulphide, and deposit at the same time a precipitate of almost white sulphur. This precipitated sulphur is dearer than the foregoing, it contains sulphuretted hydrogen and alkaline sulphides. (5) *Mixtures containing sulphur*—In nature sulphur often occurs mixed with gypsum, carbonate of lime, sand, in proportions varying from 5 to 40 per cent. Such minerals are ground finely and marketed as Apt sulphur and Briabaux sulphur. The "Minerale Greggio," extracted in Sicily, is an earth containing 40 per cent of sulphur, 2 per cent. of alkaline carbonate, 11·8 per cent. of carbonate of lime, 42 per cent of magnesia, 36 per cent. of sulphate of lime, a little iron, clay, and arsenic The value of these mixtures depends on their sulphur content; the gypsum and carbonate of lime have no anticryptogamic property. In many cases they are preferred, and that is what has contributed to the preparation of artificial mixtures containing 10—50 per cent of sulphur only. The Fonta powder contains 10 per cent. of sulphur and 90 per cent. of talc. A marble worker of Saint-Beat, having tried a mixture of 50 per cent. of ground marble and 50 per cent. of sulphur, found that this very efficient treatment occasioned no scorching on the vine, even during great heat. Neutral mixtures have, therefore, been prepared for this purpose, containing 50 per cent of sulphur and 50 per cent of gypsum, carbonate of lime, or clay. Now that cryptogamic diseases, like mildew and black rot, have invaded the vine already attacked by oidium, attempts have been made to reduce the multiplicity of treatments by mixing sulphur with cupric powders. These powders, such as "Cupro-Calcite," will be dealt with when treating of oidium and mildew [1]

Use.—The use of sulphur goes back to 1846. It was by rule of

[1] Mildew of the Vine. PERONOSPORA VITICOLA.—This fungus has great analogy with the *Phytophthora* It prefers to grow on the leaves of the vine, but it also invades the young branches, the flowers, and the grapes. (*Brown* rot, grey rot, juicy rot) The leaves begin to grow yellow on the attacked vines, then the spots are intensified and the vines assume a reddish-brown colour This fungus lives between the cells and the parenchyma and on the under surface of the leaf emits conidiophora from which the conidia or summer spores are detached. These ripen in a night and germinate as soon as they fall on a leaf rendered moist by the dew or by the rain, they produce mobile zoospores After a sojourn of half an hour in a drop of water, they fix themselves, emit a germinative tube which pierces the epidermis and penetrates into the interior of the leaf. Late in the season, winter spores are formed in the leaves which remain active and live in the withered leaves. In the spring the spores spread the disease. Mildew appears early in May and June.

thumb that the remedy was first discovered by the gardener Kyle, in experimenting in the greenhouses of Lyton with mixtures of sulphur and lime. At that time sulphur was already known as capable of curing mildew, and some gardeners used it. But when, in 1848, the oidium appeared, destroying the crops in the neighbourhood of Paris, J B Dumas, the Minister of Agriculture, ordered the disease known as *Oidium Tuckeri* to be examined, and the different remedies recommended to combat it to be tested. It was thus that Duchartre, Professor of Botany at the Agronomical Institute of Versailles, aided by Hardy, the gardener of the palace, undertook the study of the action of sulphur, and that he decided it to be efficient against the oidium. Gouthier, horticulturist at Montrouge, constructed at this time a bellows for sulphuring, which contributed much to spread the use of sulphur around Paris. Henceforth, owing to this use of sulphur it was possible to contend against the oidium, and in 1852 and 1853 the vines of Chasselas and Thommery were entirely preserved Sceptical vine-growers, persuaded that the oidium could only develop on perishing vines, sought at the same time a remedy by improving the culture. There were long gropings in the dark, unsuccessful years, nevertheless, owing to the persevering efforts and profound study of Mares, a vine-grower of Herault, the action of sulphur on oidium was not long left in doubt From 1857 sulphuring has spread more and more, and owing to this treatment oidium is no longer propagated to such an extent as to cause serious damage in vineyards. To contend against this disease France alone consumes 100,000 tons of sulphur per annum.

How does Sulphur Act?—The different kinds of sulphur sold in commerce have not the same anticryptogamic value. In a general way that value is proportional to their pure sulphur content and to the fineness of division. Precipitated sulphur and blown sulphur are the products which attain the highest degree of fineness, sublimed sulphur and ground sulphur come very near them In the manufacture of ground sulphur great progress has been realized of late years, formerly, in fact, it required 80 lb. to obtain a result analogous to that got from 40 lb. of sublimed sulphur, whilst now equal weights of these two products have the same anticryptogamic value. The adherence of the sulphur to the leaves depends on its fineness. From this point of view blown sulphur and precipitated sulphur are much superior to sublimed and ground sulphur, but the former are too dear. In extensive exploitations where they used sublimed sulphur almost exclusively, they have begun to replace the latter by ground sulphur, which has the advantage, like blown sulphur, of containing neither sulphuric acid nor sulphurous acid, and thus does not burn the leaves during great heat. To obviate the drawbacks which sublimed sulphur has of grilling the leaves and irritating the eyes of the operators, it has been ground with inert bodies capable of neutralizing the acids which it contains. Neutral mixings, with a much more gentle action on the plant, and which act in the same way as the neutral sulphur above described, are thus obtained. It is thus that mixtures containing gypseous, bituminous, calcareous ingredients are met with, which have at the same time the advantage of favouring adherence in rainy weather. Many preparations are used in the south of France, and in Algeria, where they

are specially applied for August treatment, but a larger amount must be used in inverse proportion to the sulphur content It was interesting to know the action of sulphur on fungi living as parasitics on plants, and several scientists devoted themselves to this study. It is recognized that the destruction of the parasite is more rapid the warmer the weather. With a temperature of 30—40° C. (86—104° F) destruction occurs in one to three days, from 25° C. to 30° C. (77—86° F) it is already slower and takes four to five days, below 25° C. (77° F) it is still more slow. According to Mach, Vesque, Sorauer, Hollrung and Dufour, this action of sulphur on the mycelium of fungi results from the formation of sulphurous acid, formed by the slow combustion of sulphur under the action of the sun and heat. Pollacci, on the other hand, believes that the sulphur is transformed into sulphuretted hydrogen, the vapours of which have a very energetic action on fungi. The third opinion is that of Mares and Mohr, who believe that the sulphur acts of itself, *i e.* by its own vapour. The first hypothesis seems in fact inadmissible, for the simple reason that the sulphur cannot be transformed into sulphurous acid except at high temperatures and only by its combustion. But the sulphur does not act only on the mycelium of the fungi where it is in contact with it, sulphur placed at a distance acts equally well. Spread on the soil around the plant, it acts perfectly well if the temperature reaches 25—30° C. (77—86° F.) This observation was noted as regards greenhouses by Bergmann, Lord Rothschild's gardener, and by Viala, for vines in the open air. If it be therefore recognized that sulphur acts by the vapours which it emits, the nature of such vapours remains to be examined Sulphurous acid must not be dreamt of, $\frac{1}{10000}$th of this acid in the air would burn the leaves. In warm and cold greenhouses where the plants are unceasingly exposed to the vapours of the sulphur emitted from the sulphur spread on the soil, these would not resist long if the ambient air contained sulphurous acid. The effects of this acid, to be examined further on, are disastrous to plants, and if it be admitted that sublimed sulphur burns plants, this drawback is only due to the presence of sulphurous and sulphuric acids. The formation of sulphuretted hydrogen is equally impossible. To determine what the nature of the vapours emitted from sulphur when it is spread on the leaves and the soil and exposed to the action of the air and the sun may be at temperatures of 25—40° C. (77—104° F.), the author (Bourcart) made a series of laboratory experiments. Sulphur mixed with dry or moist soil with or without humus was placed in flasks with a tubulure. After having arranged these flasks on a water-bath heated at 35—50° C. (95—122° F.), pure oxygen or a simple current of air was passed over these mixtures and the experiments were kept up for eight days. At the exit from the flasks the gas passed through a series of bottles containing substances to retain sulphurous acid in some, hydric sulphide in others. Analyses made of the liquids collected and of the soil mixed with sulphur gave no trace of sulphurous acid, nor of hydrogen sulphide, hyposulphite, or sulphuric acid. Between 25 and 50° C. (77—122° F.) therefore sulphur undergoes no chemical modification, and if it acts at this temperature on fungi it is by its own vapours. The odour of a greenhouse or a vineyard is in fact never that of sulphurous acid or hydric sulphide but that of sulphur.

There is another reason in favour of the sulphuring of vines. Sulphur would appear in fact to have a direct action on vegetation which it renders more vigorous; it favours fecundation and otherwise stimulates the maturity of the grape which generally ripens eight days earlier. It is therefore advantageous to sulphur the vine even in the absence of cryptogamic parasites.

Recent experiments (1924) on the fungicidal action of sulphur in the U S A. have shown that sulphur is toxic only in the presence of oxygen, that the active principle is volatile, and that precipitated sulphur is more toxic than finely ground sulphur Young, as a result of his extensive researches on the toxic property of sulphur, concludes that toxicity is exhibited only when oxygen and water are present and is due to the formation of pentathionic acid, a volatile oxidation and hydration compound of sulphur Finely divided sulphur is more readily oxidized to pentathionic acid than flowers of sulphur—a fact which explains the greater effectiveness of colloidal sulphur. Wettable sulphur sprays have been found somewhat difficult to prepare, as the sulphur alone refuses to mix with water; a formula recommended in Nova Scotia is about 67 per cent superfine sulphur, 30 per cent. hydrated lime, and 3 per cent. calcium caseinate, this mixture to be used at from 30 to 50 lb. per 100 gallons, with the addition of 2 lb lead arsenate. The ingredients should be mixed beforehand in a dust mixer This mixture is said to cost about the same, or very little more than the standard 3 : 10 40 Bordeaux, is quite harmless to foliage or fruit, and is superior in the control of all insects

The usual distinction made between precipitated (hydrophobic) sulphur and a true hydrophilic colloidal solution is largely in the size of the particle. The latter is made by passing hydrogen sulphide through a saturated solution of sulphur dioxide until the odour of the latter cannot be distinguished This is important, as if free sulphur dioxide remains in the solution it is apt to scorch foliage. This is a stable preparation, in which the particles aggregate but slowly. Hydrophobic colloidal sulphur is prepared by precipitating lime-sulphur solution by adding concentrated hydrochloric or sulphuric acid. The acid was added to the solution to a point of acidity as shown by methyl orange, about 0·5 c c concentrated acid per 10 c c of lime-sulphur concentrate (1·3° Bé.) being usually required. Such solutions tend to aggregate sulphur particles up to a point of precipitation within a few days Glue or gelatine delays this process, especially if added before the acid. For commercial purposes 1 lb. of glue dissolved in water is first added to 5 U.S. gals lime-sulphur solution, then in addition, 2 to 4 U.S. pts of concentrated acid, or until the yellow colour disappears and the solution is slightly acid to methyl orange. A larger amount of glue is required if the solution is to stand several days before use. In these preparations the sulphur particles are so finely divided that they are invisible at a magnification of eighty times and are more active than the finest of ground or flowers of sulphur now in use

Toxicity tests with the U S red spider (*Bryobia prœtiosa*) show that colloidal forms of sulphur killed about 99—100 per cent.; 2 per cent. lime-sulphur solution plus 5 lb. ground sulphur per 100 U S. gals. killed 90·6 per cent.; ground sulphur dust killed 44·9 per cent. These

applications were made in June, the maximum temperatures of the days following them being 71—78° F At higher temperatures the differences were less marked, but even then the colloidal forms were always superior. Colloidal forms of sulphur, particularly the hydrophilic solution, are more dangerous to foliage even than lime-sulphur solution. Under California conditions, where most of the work on red spider is done at high temperatures, it is doubtful if colloidal solutions could be economically substituted for lime-sulphur solution containing free sulphur, at least until an inexpensive process of manufacture is established

How Should Sulphur be Applied?—Sulphur is generally used as a curative agent, and sometimes as a means of prevention. There is no absolute rule for applying sulphur, the essential point is to do it at the right time. The adhesion of sulphur can, in fact, be increased by applying it when the plants are still covered with dew, or after artificial moistening, but that is not indispensable, for dry sulphur generally adheres well enough on the leaves, and chiefly on the diseased parts. The mycelium of the *Erysipheæ* retain, in fact, lumps of sulphur, which persist longer on the spots attacked than on the healthy spots. If a persistent rain comes on or a storm in twenty-four hours after sulphuring, it is well to repeat the operation. Sulphuring may be done at any hour of the day. The dose of sulphur should suffice to cover entirely the diseased parts. During great heat it suffices to spread the sulphur on the ground at the foot of the plant Sulphuring has been used preventively in greenhouses to prevent all cryptogamic diseases from appearing. The sulphur is spread on the soil, or on the heating pipes once a year. The plants thus live in a special atmosphere containing sulphur, which is opposed to the development of fungi, without injuring the plant Different utensils have been used to spread the sulphur. The most simple is a vessel of tinned iron, the bottom of which is perforated. It is filled with sulphur and shaken above the diseased plant. This instrument, however, much used in the south, has the drawback of spreading the sulphur very irregularly, and in too large quantity on the diseased plant Another type is constructed on the same style, but it contains meshes of wool which sift the sulphur and distribute it more regularly. But these primitive instruments have been almost everywhere replaced by bellows or blowers. The first was constructed by Gonthier, and greatly helped to popularize sulphuring. This is the bellows still used in gardens. It consists of a box to contain the sulphur, which is fitted with a flat pipe at one of its extremities and an ordinary bellows at the other. For large vineyards there is a more practical instrument, which carries a larger quantity of sulphur. It is a sort of *hood*, called a *soufreuse*, which the workman places on his back, and which can contain 10—12 kilogrammes (22—26·4 lb.) of sulphur. It is filled by an air-pump, with fan, which is wrought by a lever and a projector, the extremity of which, ending in a Raveneau jet, distributes the sulphur as a mist. It can treat 1—2 hectares ($2\frac{1}{2}$—5 acres) a day. It must be perfectly cleaned after each operation, so that the sulphuric acid of the sulphur does not damage the metal part The action of the sulphur on the *Erysipheæ* is unquestionable, the mycelium of which, crawling on the surface of

the organs attacked, is quickly disorganized All the mildews may therefore be effectively overcome, and it suffices for the purpose to sulphur at each approach of these parasites But the use of sulphur does not stop there. In certain cases, in fact, where the mycelium cannot be destroyed, as the plant itself protects it, it destroys the external organs of fructification, such as the *Conidiophoreæ*, and prevents the disease from assuming too great an extension by that alone It is thus that sulphur acts on certain *Peronosporeæ* [1] and *Black blights.* Diseases of a bacterian nature may sometimes be contended against preventively by the disinfection of the seed by sulphur. Sulphur also acts energetically on certain insects with a soft skin, and, according to Berlise, its

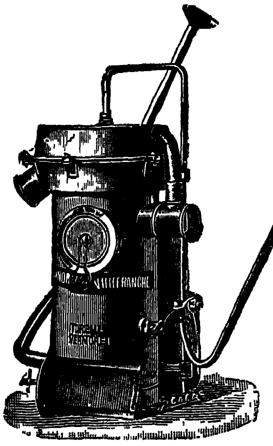

Fig 5 —Torpedo Sulphur Distributor.

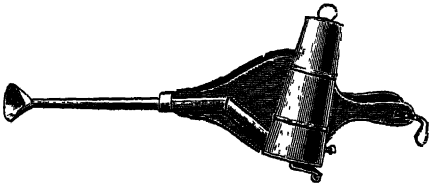

Fig. 6.—Regulator Sulphur Bellows.

action is rendered more efficient by steeping it in wood tar and then drying it. It has been found, however, to have no action on plant lice or cochineal.

Use against Bacteria.—Amongst the bacterian diseases of plants the following can be treated with sulphur —

Rottenness or Moist Gangrene of the Potato [2] ; *Potato Scab* [3] , *Rottenness of the Sweet Potato* (*Batates edulis*).—Nijpels and Stone recommend the use of sulphur preventively against these diseases. They advise that the potatoes intended to be planted be rolled in flowers of sulphur after being completely moistened so that the flowers of sulphur adhere more completely. They also recommend flowers of

[1] Peronospora (mildew and white rust) —Fungi of which the mycelium lives in the interior of the tissues and which produce on the surface of the attacked organs whitish tufts resembling blights.

[2] Rot or Moist Gangrene of the Potato.—This disease is a complete disorganization of the plant which is attributed to the action of the *Bacillus amylobacter* (Kramer) and according to American specialists to the action of *Oospora scabies* (Thaxt).

[3] Potato Scab —This is due to the growth of an aerobic bacteria in the living tissues of the circumference of the tubers.

sulphur to be spread in the furrows in which the potatoes are planted Halsted estimates that manure with 170 kilogrammes of sulphur per hectare, say 150 lb. per acre, especially if it be accompanied with a manuring of 175 kilogrammes per hectare (154 lb. per acre) of kainit, gives results quite as satisfactory as the usual disinfection of the tubers by corrosive sublimate. Nijpels, who controlled these experiments, found, however, that his own process gave a better result.

Use against Fungi.—Amongst the *Peronospora* we may quote *Cystopus candidus*,[1] Lev. (white rust of the *Cruciferæ*), *Cystopus cubicus*,[1] de By (white rust of the *Compositæ*) The sulphuring recommended by Weiss to combat white rust can have no effect, except preventively, at the time of lifting the seed. Then several sulphurings are applied, working preferably in the morning during the dew.

Uredineæ (rusts injurious to cereals).—Sulphur has no action on these diseases, the mycelium of which grows exclusively in the body of the nurse plant, and the spores of which are generally formed under the epidermis of the plant Amongst the *Erysiphe* we may quote *Erysiphe communis*, Wallr (mildew of the pea and bean). We can efficiently contend against this fungus, either by the use of sulphur or of sulphur and lime. Prillieux holds that sulphuring done as soon as the first spots appear may completely save the crop invaded In the same category the most important of all the diseases, that which has caused the greatest ravages, is, without doubt, the disease known under the name of *Uncinula americana*, How. (oidium of the vine). Since the decisive researches of Mares, vine-grower of Herault, it has been possible owing to the use of sulphur to contend victoriously against this plague without, however, causing it to disappear completely. It is quite as lively as when it first appeared, but by the rational application of sulphur its development can be circumscribed and its action on crops prevented. The disease always assumes new vigour when vine-growers are negligent in the execution of this treatment. But so that the latter may be absolutely efficient, it must be practised in special conditions It is evidently difficult to fix in a precise manner for all regions the number of sulphurings to apply and the proper times, so as to protect the vine from invasion. Moisture and heat are, in fact, important factors of the development of the oidium; the questions of climate, of exposure, of the year itself, have a great influence on the time of treatments and their number. There are two methods of sulphuring vines: (1) *The repressive method*, which consists in sulphuring each time the disease appears on a certain part of the vine. That requires great attention on the part of the vine-grower, who should not let the disease extend too far. (2) *The preventive method*, which is most in use, consisting of three sulphurings at fixed intervals. The first sulphuring is applied when as yet no oidium has been observed at the time when the young branches reach 8—10 centimetres (3·2—4 inches) in length. The second at the time of flowering,

[1] Rust, White, of Cruciferæ *Cystopus candidus.* Rust, White, of Compositæ *Cystopus cubicus.*—The hyphæ of the mycelium of these diseases glide between the cells of the nurse plant and there sink their suckers The conidiophora form white pustules which are found indifferently on the surface of the leaves, stems, flowers, and fruit, for the fungus invades all the plant and causes it to undergo very curious deformations.

and the third some days before *veraison*, taking care to sulphur the grapes chiefly. A supplementary sulphuring may be intercalated between the second and the third if special conditions are favourable to the reappearance of the disease at that moment Dufour advises two treatments before flowering, the first, before the complete expansion of the leaves, the second a little before flowering Spring sulphurings in no way injure the plant, and they may be executed at any hour of the day But those which must be made in the hot season may injure the vines, the leaves of which are burned by the sulphur under the action of the sun. It is then necessary to comply with the following indications :—

(1) To use neutral sulphurs, chiefly mixtures, containing but little sulphur, instead of flowers of sulphur, always slightly acid, and because the former have a much more gentle action than pure sulphur. (2) To spread the sulphur preferably on the soil, instead of projecting it directly on the plant. This process is not only efficient, but without the drawbacks described above (Viala). When these few precautions are neglected, a large part of the crop is liable to be lost, owing to the corrosive action of the sulphur. The dose to apply at each sulphuring depends on the state of growth of the vine and the system of planting. For the first treatment it is well to use 15—20 kilogrammes (33—44 lb.) of flowers of sulphur per hectare (13·2—17·6 lb. per acre). At the time of flowering the dose is raised to 30 kilogrammes of flowers of sulphur (66 lb. per hectare, 26 4 lb. per acre) or 50 kilogrammes (110 lb. per hectare, 44 lb per acre) of ordinary ground sulphur. Finally for the third operation it is necessary to spread 40 kilogrammes of sublimed sulphur (88 lb per hectare, 35·2 lb. per acre) or 60—70 kilogrammes of ground sulphur per hectare (52·8—61·6 lb. per acre) and about 100 kilogrammes of Apt sulphur (220 lb per hectare, 88 lb per acre) When the ground sulphur is as fine as the sublimed, the quantity to use will be the same as for the latter. To preserve hothouse vines, it suffices to spread sulphur on the soil once a year; any invasion is prevented by this single treatment. Since other cryptogamic diseases—mildew, black rot, and others—have ravished the vine, attempts have been made to reduce the multiplicity of treatments, and cupric powders have been mixed with the sulphur, the isolated action of which is recognized as efficacious against these diseases. It has been advised to add 5 per cent. of blue vitriol to the sulphur, or to incorporate sulphur in the cupric bouillies. A preparation known under the name of "cuprocalcite" has in Germany the reputation of being at 25° more active than sulphur (Mohr) This product would appear to form a protective coat on the leaves, and by its adherence preserves the plants longer against new invasions of oidium. But this opinion is not accepted, and it is generally believed that sulphur does not act in the presence of common salt. Pollacci and P. Viala condemn these mixtures, the first, because he believes that sulphur is not oxidized in the presence of copper salts, the second, because the experiments made at the Montpellier schools showed that these mixtures could neither prevent nor arrest the oidium and mildew. Mach and Mares agree upon that point, and this is the explanation : Copper salts have, in fact, the drawback of catching the vapours of sulphur, converting

them into insoluble and inactive copper sulphide If it be taken that sulphur acts by its vapours, it is evident that the action of the product is destroyed. These remarks are also of value in regulating the double treatment with sulphur and cupric bouillies Since the introduction into viticultural practice of sulphating against mildew and black rot, the question of ascertaining whether sulphuring should be done before sulphating, or *vice versa*, has been often discussed Laurent advises to precede the first sulphuring by the first sulphating, the second sulphating being done after flowering But as the sulphur acts for four to five days, it is well to let this interval elapse between sulphuring and sulphating, so that these two treatments do not mutually destroy the effects of each other

Drawbacks to Sulphuring.—Workmen engaged in sulphuring with sublimed sulphur sometimes have bad eyes, especially if they do not take the precaution to work with the back to the wind To obviate this drawback, it is well to make them wear spectacles with cloth side-pieces, and to make them bathe the eyes several times a day with fresh water Sulphur also gives sometimes a slight taste to the wine, owing to hydrogen sulphide, formed during fermentation But this drawback is always caused by too dilatory sulphuring If the wine still contains sugar, and is fermenting, it must be drawn off after fining in a cool cellar If it does not contain sugar and is already drawn off, it must be protected from any new production of hydrogen sulphide by the following treatment. In the case of wine with a feeble taste, one or two drawings off, during which the liquid is allowed to flow in a thin stream into a tank, may suffice to let the hydrogen sulphide escape into the air L. Mathieu advises running the wine in a stream over a plate of polished copper, so that it runs into a film · one part of the gas escapes into the air, the other is fixed by the copper. The copper plate must be cleaned from time to time with emery paper when it is blackened. If these methods do not suffice, sulphurous acid must be added to the wine as bisulphite of potash (metabisulphite of potash), about 10 grammes per hectolitre, say 7 grains per gallon. The two gases mutually destroy each other with the deposition of sulphur, which simple fining after a few days will completely carry down into the lees. By using for the last operation only 40 kilogrammes of sublimed sulphur per hectare (35·2 lb per acre) or a stronger dose of Apt sulphur or any other product of low sulphur content, this drawback need not be feared.

Oidium fragariæ, Harz (oidium of the strawberry).—Sulphuring gives excellent results (Sorauer); *Phyllactinia suffulta*, Rebent. (mildew of the hazel and the ash-tree); *Microsphæra grossulariæ*, Wallr. (mildew of the gooseberry leaf).

Sphærotheca Castagnei (mildew of the hop).—Nijpels recommends to fight it, like the oidium of the vine, by three sulphurings, the first before flowering, the second during flowering, and the third when the cones are completely developed.

Sphærotheca pannosa, Lev (mildew of the rose and the peach).—By methodical sulphuring, applied as soon as the disease appears, the rose bushes, most sensitive to this mildew, may be quickly cured The curative treatment of the peach miller (*meunier du pecher*) also consists in two or three sulphurings applied after ten days' interval.

Fumagine (smut of fruit trees).—Sulphur has the same action on capnodium as on mildews, but to be completely successful it is necessary to fight the lice and the cochineal, which are the first cause of the fumagine. Amongst the *Sphæraceæ* capable of being fought with sulphur there may be mentioned :—

Dematophora necatrix [1] (white root rot of vine, etc.).—Narbonne has tried sulphur against vine rot. He advises to pull up the most badly attacked stocks; to lay bare the stocks not so badly attacked as deep as possible, and dust the roots abundantly with sulphur. It is useful to renew this operation several times before the stocks are covered up again.

Black Blights, the mycelium of which is in the interior of the plant, are more difficult to reach by sulphur, but as their organs of fructification, the conidiophores, are formed on the surface of the leaf, those organs can be got at by sulphur. The propagation of the disease is thus fettered. In this class are :—

Sphærella fragariæ,[2] Sacc. (spots of the leaf of the strawberry).—This very common and often harmless disease may, when it is intensely severe, stop the development, and entail the death of the plant. Nijpels recommends sulphur mixed with lime to prevent the disease on young plants.

Septoria petroselini, Dmz. (var. Ap. Br. et Cav.), injurious to celery, is fought by sulphuring, like the *Cercospora apii*.

Gloeosporium ampelophagum, Sacc. (grape rot).—This disease may be fought by sulphuring, but to succeed it must be applied in the beginning of the attack, so as to hinder the germination of the spores. To stimulate the action of the sulphur it is mixed with pulverized iron sulphate or lime. P. Sol advises a very abundant first sulphuring before flowering, to distribute them plentifully in the same spots, and then to sow ferrous sulphate broadcast, 50 kilogrammes per hectare (44 lb. per acre). If the epidemic be not arrested it is necessary to renew this treatment. Viala obtained good results from mixture of sulphur and lime applied in the following proportions :—

TABLE X.—*Showing Proportions of Sulphur and Lime used in Mixtures against Anthracnose* [3] *at Different Stages of Treatment*

	First treatment.	Second treatment.	Third treatment.
Sulphur	4 parts	3 parts	2 parts
Lime	5 ,,	2 ,,	3 ,,

The first treatment is applied when the shoots are 8—10 centimetres

[1] DEMATOPHORA NECATRIX (white root rot).—This fungus lives at the expense of the roots of the vine, fruit-trees, mulberry-trees, fig-trees, maple-trees, oak-trees, and soon kills the tree. The white root rot is especially attributed to the *Sphæriaceæ dematophora*, but this fungus is not the only one capable of producing this physiological condition of fruit trees.

[2] SPHÆRELLA FRAGARIÆ (spots of the leaves of the strawberry).—The leaves attacked by this fungus are covered with purple-brown rounded spots, separate or contiguous, which appear on their upper face. They increase rapidly in size, wither in the middle, and are finally pierced right through.

[3] ANTHRACNOSIS OF THE VINE (grape rot). *Gloeosporium ampelophagum*.—The filaments of this fungus live inside the cells and produce spots on all the herbaceous parts of the vine, each forming small ulcers gnawing the tissue as far as the soft parts of the liber. The branches are contorted and blackened.

(3·2—4 inches), the succeeding treatments every fifteen days. Briosi tells us that this sulphur and lime treatment is in actual use to fight anthracnose in the provinces of Pavia, Cuneo, and Messina. Solutions of sulphate of iron are reserved for winter treatment.

Cercospora apii, Fr (celery leaf blight) —Sturgis, Duggar, and Baily agree as to the efficacy of sulphur in fighting this disease when applied on a hot day, in which case sulphur is superior to all other chemical agents. Scribner dissents, and asserts that sulphur has little or no action. It is evident that sulphur cannot reach the fungus developed in the interior of the leaf, but in destroying the organs of fructification it may stop the propagation of the disease

Cladosporium fulvum, Cooke (tomato leaf rust) —Mohr and Nijpels found that sulphur acts more effectively than copper salts to arrest this disease.

Clematite (large flowered), variety of *Clematis patens, lanuginosa et florida, disease of*—This disease, to which many fine ornamental plants succumb, is attributed to the *Aecidium clematidis* or *Aecidium englerianum*, sometimes to *Nematodes*. The clematites disease cannot be circumvented by copper salts. But Fourrat found it possible to prevent it by laying bare the root, which he dusted with sulphur and afterwards covered with soil. The author's (Bourcart) experiments did not confirm this result.

Use of Sulphur against Insects.—*Crioceris asparagi*,[1] L.—Miss Ormerod killed these insects by a spray consisting of 1 lb of soap, 1 lb. of sublimed sulphur, and 1 lb of soot, in 10 gallons of water.

Haltica nemorum, L. (earth flea).—These minute Coleoptera gnaw the leaves of young plants, and, owing to their numbers, cause great damage. Their destructive work may be stopped by dusting the plants, whilst still small, with a mixture consisting of 3 kilogrammes (6·6 lb) of sublimed sulphur, 5 kilogrammes (11 lb.) of soot, and 50 litres (1¾ bushels) of quicklime per hectare (2½ acres). In the author's opinion the quicklime would have a preponderant action.

Haltica ampelophaga, Guer. (altise of the vine [2]).—D'Aurelles de Paladines proposes to fight them with sublimed sulphur, or better, precipitated sulphur from gasworks. A more energetic method consists in using a mixture of black snuff, 12—15 kilogrammes, and Apt sulphur, 85—88 kilogrammes per hectare (10 4—13·2 lb. and 74·8—77·4 lb. per acre) A mixture of Apt sulphur and newly slaked lime may also be used.

Ephippigera bitterensis (*Ephippiger of Beziers*), *Ephippigera vitium* (vine ephippiger) —These grasshoppers devour the leaves, the young vine shoots, and the grapes The crop is sometimes seriously compromised in the South of France by the great number of these Locustides. The grapes may be protected from their voracity by dusting the bunches

[1] CRIOCERIS ASPARAGI (asparagus beetle).—Coleoptera (chrysomelide) of 6 millimetres in length, steel blue elytra, with four bright yellow spots

[2] ALTISE OF THE VINE *Haltica ampelophaga* (vine flea).—Small greenish-blue insect, 5 millimetres The female lays its eggs at the end of April on the under surface of the leaf, the larvæ appear ten days afterwards; they burrow long grooves into the parenchyma; in ten days they reach full size, let themselves drop on the soil and there bury themselves to the depth of 2 inches; two weeks afterwards the perfect insects appear.

in June, at the time when the Ephippigeres appear, with a mixture containing equal parts of sulphur and lime.

Eriocampa adumbrata [1] (slug worm, or slimy caterpillar of pear-tree saw-fly)—Goethe recommends ground sulphur against the sticky larvæ of this saw-fly. This treatment is in common use in the Tyrol.

Carpocapsa pomonella,[2] L. (codlin moth), the grub of which renders apples wormy. The sulphuring of apple trees, after flowering, is very efficient in drawing off the butterfly and preventing it laying its eggs on the young apples.

Success has been obtained in the U.S.A with the wettable sulphur sprays, against codlin moth (*Carpocapsa pomonella*) and red bug (*Heterocordylus malinus*). The formula was 4 lb. hydrated lime, 8 lb. sulphur and 1½ lb. powdered lead arsenate to 50 U S gals of water, with 1 lb calcium caseinate or 4 ozs glue per 100 U.S. gals as a spreader. While on the average not quite so effective as lime-sulphur solution in controlling apple scab, these sprays have proved safer on apple foliage.

Phylloxera vastatrix (phylloxera of the vine).—Two processes have been used; that of Saintpierre, tried unsuccessfully, is quoted as a matter of history It consisted in making a hole in the vine with a gimlet and in introducing 3 grammes of sulphur, then in re-closing the hole with a plug. The second process, that of Aman-Vigie, consisted in injecting into the soil, by means of a special bellows, a mixture of sulphur and sulphurous acid. But these vapours do not diffuse well in the soil and only penetrate it imperfectly. Henneguy, after trying this process, concluded that, applied in July and August, it exerted an unfavourable action on the propagation of this insect. If it be not capable of entirely freeing the vine from its parasite, it kills a sufficient number to allow the plant to live normally.

Use against Acari.—*Tetranychus telarius*, L (red spider so-called).—In hothouses it may be fought with sulphur. Maynard advises heating the sulphur in a pot till it gives off fumes without inflaming. This operation should be renewed two or three times a week for several months. Sturgis asserts that this process destroys at the same time the *Peronospora*, de By., which resists repeated sulphurings in the open air.

Tetranychus bioculatus, W M. (red spider of tea).—Playfair recommends to destroy it to spread on the tea before cutting 50 to 60 kilogrammes of sulphur per hectare (44—52·8 lb. per acre)

Eriophyes vitis, Land., syn. *Phytoptus vitis* (erinosis [3] of the vine).

[1] ERIOCAMPA ADUMBRATA *Selandria atra* (the slug-worm or slimy caterpillar).—Saw-fly, of a brilliant black with a transversal brown band on the upper wings. The larvæ are first of a blackish-green, then of an amber-yellow and covered with a viscous substance; it vaguely resembles a small snail, hence the name slug-worm. They devour the parenchyma of the cherry-tree, the pear-tree, the plum-tree, and the apricot-tree.

[2] CARPOCAPSA POMONELLA (pyralis of the apple-tree) (apple-worm, codlin moth)—Moth of ½—1 centimetre long, ashy-grey wings striped crosswise with small dark sinuous lines, with bronze reflex lustre and marked at the extremity with a brown spot encircled by a gilded yellow line. After fecundation the female lays its eggs one per fruit on the epidermis of the new-formed fruit and on the surrounding leaves.

[3] ERINOSES *Phytoptides* (gall mites).—The irritation caused by the bite of certain acari, the Phytoptes, causes alterations in the epidermal cells of the leaves

—Erinosis may be arrested by repeated sulphuring, commencing some time after the formation of the buds, when the branches are 8—10 centimetres (3 2—4 inches) in length Couderc advises a hot day in spring for the operation

Eriophyes malinus, Nal , syn. *Erinium malinum* (erinosis of apple and pear).—Sulphuring applied from bottom to top produces a satisfactory effect.

Eriophyes piri,[1] Pgst C (brown rust of the pear), syn. *Phytoptus piri*.—Repeated sulphurings are efficacious if applied before the appearance of the disease.

Phyllocoptes Schlechtendali,[2] Nal. (browning of leaves of pear and apple trees) —This fungus is readily attacked by insecticides, and sulphur acts in a sure manner.

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which elongate under the form of hairs and form a felt, generally in the lower part of the leaves, which may be white, yellow, rose, or rust colour These diseases are widespread ERINOSIS OF APPLE-TREE AND PEAR-TREE. *Erinium Malinum et Pirinum*.—Felting of under part of leaves, passing from yellow and rose to rust colour ERINOSIS OF THE GOOSEBERRY. *Phytoptus ribis* —This acarus sucks gooseberry buds and leaves, the branches never develop and form packed branches of leaves ERINOSIS OF THE VINE. *Phytoptus vitis, Eriophyes vitis*.—Leaves attacked by this Phytoptus show irregular-shaped swellings on the upper surface, and are coated on the under surface with down. White at first, the down becomes red, then brown, as it ages.

[1] ERIOPHYES PIRI. *Phytoptus piri* (rust of the pear-tree).—This disease is produced by an acarus which dwells in the parenchyma of the leaf and circulates between the two epidermes The irritation of its bites causes the formation of pustules, the red tint of which on the young leaves becomes brown and even black in a few weeks

[2] BROWNING OF THE LEAVES OF THE PEAR-TREE AND APPLE-TREE. *Phyllocoptes Schlechtendali* —The acarus which produces this browning lives freely on the surface of the leaf, it neither produces galls nor felting.

CHAPTER III

CARBON DISULPHIDE, CS_2

Carbon Disulphide.—Preparation.—By passing the vapour of sulphur over red-hot charcoal. On the large scale, vertical cast-iron cylinders built in masonry are used They are filled with charcoal, which is kindled. As soon as it has reached a sufficient heat, the sulphur is introduced, gradually, through a side pipe. The sulphur melts, then vaporizes, and combines as vapour with the incandescent carbon. The gas escapes through a top pipe which communicates with two reservoirs, the first of which retains entrained sulphur, the second, which is cooled by a bath of cold water, condenses the vapours of carbon disulphide. The uncondensed gases, which are hydrocarbons, escape through a top pipe Carbon disulphide flows into zinc reservoirs, where it is preserved under water. It may be rectified by drying it over fused calcium chloride and finally distilling it on a water-bath For agricultural purposes, this rectification is useless; carbon disulphide in that case is led directly from the tank into the wrought-iron barrels, in which it is dispatched. Another method of preparation is by heating carbon with sulphur in an electric furnace and condensing the CS_2 vapours.

Properties.—Carbon disulphide is a colourless liquid with a pleasant smell when it is pure, but almost always fetid on account of impurities which it contains. It is a very mobile liquid, which boils at 45° C. (123° F), and consequently vaporizes with rapidity in an open vessel. Its vapours form with air mixtures capable, like coal gas, of detonating at the approach of a flame or an incandescent object Owing to its ready inflammability the manipulation of carbon disulphide necessitates great precautions, and should be carried out far from any source of heat or flame, and wholly in the open air Smoking is therefore forbidden in the sheds where it is handled, and when it is employed in the field the iron barrels containing this product should be deposited far from dwellings, and protected from the sun. To prevent the losses which would result from the evaporation from a cask being emptied, a good precaution is to run a small quantity of water into the cask. The water forms on the surface of the carbon disulphide a protecting layer, for the density of the water is lower than that of the sulphide. To ascertain the quantity of this liquid left in a barrel, a rod coated with tallow may be dipped into it. The rod will come back clean on all the part which touched the carbon disulphide, this product being a solvent for all fats. Carbon disulphide is almost insoluble in water, the latter can dissolve at 1000th part of its weight. On the other hand, it is miscible, in all proportions, with absolute alcohol, and with a great

number of organic bodies rich in carbon, such as fats, resins, camphors, greases. It exercises a very decided deleterious action on the animal economy; it produces headache and nausea, and after a certain time it may debilitate the nervous system. Its intoxications are not generally dangerous, for they cease by the simple removal of the cause. The workmen who handle this product are subject to its effects if precautions are not taken to protect them from the vapours, those suffering from heart weakness should avoid it altogether. Carbon disulphide is used in medicine as an antiseptic against typhus, cholera, tuberculosis, against cancers, intestinal catarrh, and especially infectious diarrhœa, finally as an emmenagogue and anæsthetic. In the form of vapour it is used against helminthiasis and different diseases of the skin.

Action of Carbon Disulphide on Plants.—Carbon disulphide is poisonous to plants. According to Sandsten it stops the movements of the protoplasm as soon as the plant comes in contact with even a very small dose of this agent. It is more injurious to the plant the more its application corresponds with a greater activity of the sap The same doses used in winter without prejudicing the plants may become deadly in spring or in summer. Carbon disulphide is as injurious to the roots as to the part above ground. Plants should never therefore come in contact with pure carbon disulphide, nor into an atmosphere too highly charged with vapours of this insecticide. According to the experiments of Boiteau the roots may die if they are 4 inches from the spot where the carbon disulphide was injected into the soil. At the dose of 5 c.c. of carbon disulphide per 4 litres of soil, say at the rate of 5 oz measures of carbon disulphide per 4000 oz. measures ($3\frac{1}{8}$ bushels) of soil, the vine would inevitably die; 2 c.c. of the same product injected into the same quantity of soil (4 litres) might be injurious to a potted plant The moisture of the soil tones down to a certain extent the injurious action of carbon disulphide; its effect is so much the more injurious to the soil the more dry the soil and the higher the temperature. Just as much as contact with carbon disulphide and its vapours in strong doses are deadly to plants, so also to a like extent are weak doses indifferent to them when they are brought into contact with the roots either in 1 per cent solution in water, or in the form of vapour. The strong doses applied at the beginning of the phylloxeric invasion always entail the death of the vine, as well as that of its formidable parasite, whilst the cultural doses now used not only do not injure the vine but impart to it exceptional vigour. However, carbon disulphide produces even in a small dose, as Vincey has observed, an injurious action on the plant, but this action is only a passing one and hardly perceptible. In this way vines treated with small doses of carbon disulphide before the unhairing of the buds are thrown back seven to eight days beyond those not treated. Summer treatment always entails a passing slackening in the growth of the plant. Different plants vary in their sensitiveness to this reagent, and it has been observed, for example, that trees generally support larger doses than annual plants. The aerial part of the plant also withstands carbon disulphide up to a certain limit, soapy emulsions and fumigations of carbon disulphide which, according to Morren, are not toxic up to $\frac{1}{1,500}$. Goethe has observed that the vine can stand

fumigations for twelve hours at 20° C. without suffering Before the ascent of the sap the vapours of carbon disulphide may be prolonged without injury, and the dose in the same way. Targioni-Tozetti found that the dose of 2 per cent of carbon disulphide in soapy emulsion was the limit without injury to the leaves, whilst with petrol the dose was 2 5 per cent A strong dose of carbon disulphide dries the leaves without altering the colour Seeds likewise undergo the toxic effect of this insecticide, but according to Prillieux their power to withstand it varies with the species. Cereals, for example, lose 50 per cent of their germinative capacity after eight days of fumigation, whilst beet seeds undergo no alteration after three weeks of this same treatment. Coupin, who examined the action of this agent on grain compared with ether and chloroform, found that these two last bodies had no injurious action on wheat grain when the protoplasm is at rest, whilst carbon disulphide is always injurious thereto. However, if owing to moisture there is swelling and the protoplasm is active, ether also becomes injurious to the grain in the dose of 3·7 c c for 10 litres of air (3·7 in 10,000). According to Fantecchi's experiments seed corn dipped two minutes in carbon disulphide and afterwards dried in the air loses 10 per cent , dipped for one minute only in this insecticide, then exposed afterwards for twenty-four hours in an atmosphere of carbon disulphide, it undergoes a loss of 50 per cent The grain suffers the same loss if exposed for twenty-four hours in a closed vessel at 30° C (86° F.), in an atmosphere containing 2 kilogrammes of carbon disulphide per cubic metre if the heat be raised to 40° C. (104° F.) the loss will be 100 per cent.

The most important use for carbon disulphide as an insecticide in the United States is in the fumigation of stored grains, cowpeas, beans, and peas to kill the insects infesting them. Many species of insects are concerned, but all are susceptible to the same treatment. The most important species attacking corn is the so-called black weevil, or rice weevil, *Calandra oryza*, L , which causes a loss amounting to several million dollars annually in each of the South Atlantic and Gulf States. Investigation by the Alabama Experiment Station has shown that the amount of liquid disulphide required for killing grain insects under ordinary conditions of storage is much greater than has been recommended usually, and ranges up to about 20 lb. per 1,000 cubic feet in ordinary rooms where the walls and floor have not been made especially tight (see p 70)

Action of Carbon Disulphide on Insects.—Carbon disulphide is one of the most efficacious of insecticides, it diffuses very rapidly in virtue of its great mobility and its very low boiling-point Its anæsthetic and asphyxiant properties act very rapidly on the vitality of the insects which die paralysed in breathing it. Insects are generally more sensitive to the action of carbon disulphide than plants, so that by only using doses injurious to insects they can be overcome without hurting the plant. When an atmosphere saturated with the vapour of carbon disulphide can be created around the insects or their larvæ they die in a few seconds. Phylloxera is so killed in thirty seconds. If the atmosphere only contains 0·5 per cent. of carbon disulphide vapours (say 0·0016 of liquid sulphide) the action must last twenty-four hours

to kill the phylloxera. An atmosphere containing 0·4 per cent of CS_2 vapour easily kills, in fifteen minutes, grubs, butterflies, grasshoppers, lice, and Coleoptera. Injected into the soil to a depth of 4 inches, doses of 40 grammes per square metre (say $1\frac{1}{3}$ oz. per square yard) for heavy ground and 30 grammes (say 1 oz. per square yard) for dry, light soil, suffices to kill all the insects in that layer of earth But solutions and emulsions of CS_2 do not act so rapidly nor so energetically as the vapour in a closed space. A 1 per cent solution does not kill the phylloxera until after twenty-four hours' immersion Grubs strongly resist it. Those of the gypsy moth, *Ocneria dispar*, L., resist soapy emulsions containing up to 10 per cent. CS_2 Burleso Dufour came to the same conclusions after trying to kill the cochylis (*Cochylis ambignella*, Hubn) by emulsions containing 3 per cent and 10 per cent. of CS_2.

The way in which carbon disulphide kills has been studied at the Michigan Experiment Station, where the conclusions have been reached that carbon disulphide vapour very probably acts upon the fatty tissues in the insect body, dissolving them to some extent; that it tends to coagulate the proteins; and that it prevents the assimilation of oxygen and the carrying on of other processes which are of vital importance to insect life. A certain amount of respiration goes on at all times so long as an insect is alive, but it is evident that respiration will be far less in the egg stage or during the dormant periods in an insect's life than it is in the adult stage and during the periods of its greatest activity. The strength of vapour and the time required to kill, therefore, will vary greatly and accordingly. Similarly, slow-moving insects usually are harder to kill than the quick-moving forms.

Action of CS_2 on Fungi.—This insecticide only acts on fungi in very strong doses, and is only used to kill root rot.

Influence of CS_2 on Fertility of Soil.—Carbon disulphide, far from injuring the soil into which it is injected, as believed at the outset of its use in vineyards invaded by the phylloxera, exerts even in strong doses a favourable influence thereon Aimé Girard was the first to observe that carbon disulphide injected into the soil produced salutary effects on the soil treated and greatly improved exhausted soils. In Alsace-Lorraine, where the antiphylloxeric treatment to extinction has so long been used, the marvellous action of carbon disulphide has been remarked by Oberlin. The latter, who has more especially studied the soil cure, has obtained surprising results The culture of the vine being rigorously forbidden during the next ten years after the extinction treatment, the land was utilized for other crops. Now it was found that in all these soils all species of plants developed in a surprising manner, and that the rotations in use on non-disinfected ground were unnecessary on the former, CS_2 regenerates exhausted soils and allows continuous growing of the same crop. All *Papilionaceæ* may be profitably cultivated on lucerne ground; for example, if the soil of the latter is previously tilled and disinfected, whilst in ordinary cropping one plant cannot usually be grown after another of the same nature without intermediate crops, CS_2 therefore renders rotations unnecessary, and enables the same plant to be cultivated for several years in succession.

Oberlin, who has greatly helped to popularize carbon disulphide, got, like Girard, a double crop of trefoil after disinfecting the soil, and an appreciably increased yield with grain crops, beets, potatoes, and farm crops generally. In a tares (*Vicia villosa*) experimental field, treated with CS_2, Oberlin obtained 45 tons of green fodder per hectare (18 tons per acre), whilst in a non-disinfected field, used as a test, the yield was only 19 tons per hectare (7·6 tons per acre). He also experimented with haricots, and obtained by weight per are 85 kilogrammes in non-treated ground, and 125 kilogrammes in treated ground. Oberlin disinfects the soil as follows Holes about 12 inches deep are excavated by an iron bar and 25 grammes of CS_2 run into each hole and the holes quickly closed, 10 kilogrammes of carbon disulphide must be buried per are Three weeks after this treatment sow the seeds. Practical experiments on vines gave equally good results. Oberlin first, then Dufour, found that vineyards, before being replanted, have no need, as generally believed, of a rest, nor of any improvement by an intermediate crop after treatment with CS_2 The new vine can, in fact, be replanted as soon as the old stocks have been extirpated if the following procedure be adopted. Trench the ground to 65 centimetres (2 feet 2 inches), then at a distance of 50 centimetres (20 inches) apart in every direction dig holes of 50—60 centimetres (20—24 inches) deep Run into each 100 grammes (say 3½ oz) say 40 kilogrammes (88 lb.) per acre, and close the holes quickly, the soil must remain in this condition until the spring, when the new plantation will be made In vineyards reconstructed in that way the young vine stocks yielded in the third year 30 hectolitres (660 gallons), the fourth year, 110 hectolitres (2200 gallons); whilst the test vineyard non-treated only gave 74 hectolitres (1528 gallons) Here is, by a report of the Baden Botanical Station, a curious result obtained in onion-growing Soils, completely exhausted by the culture of this plant, were appreciably improved by disinfection by carbon disulphide. Holes 40 centimetres deep, bored 50 by 50 centimetres (20 inches) in every direction, received 100—300 grammes of carbon disulphide, and the produce, which had fallen to 14 units per square metre, was raised to 22 by the dose of 400—800 grammes per square metre, and to 26 by a dose of 1000 grammes (2·2 lb.). These improvements, due to carbon disulphide, are very surprising, and efforts have been made to ascertain how this product acts on the soil, since it is void of any nutritive function, and how it can be the cause of intense yields in an exhausted soil? [1] There are a large number of parasites, both insects and fungi, which live in the soil at the expense of the plants, and looking at their grand opportunities for multiplying when the same plant is grown continuously for several years the exhaustion of the soil, it will be readily understood, is due solely to this accumulation of parasites which, attacking the plant by the roots, remove from it the means of nourishing itself. Carbon disulphide, injected into the soil, by destroying all these parasites, restores to the soil its primitive purity, and the plant, undisturbed by parasites, develops normally, and profits, by fertilizers, to give large crops Carbon disulphide acts like the bare fallow, which also remedies

[1] *Note by Translator*—The onion is a sulphur-loving plant. The reason for increase in crop is obvious.

soil exhaustion. By suppressing food for the parasites accumulated in the soil for a certain time the latter greatly disappear. Carbon disulphide is more effective than bare fallow, and gives complete and immediate results, because it enables the soil to be completely disinfected and to utilize it at once for a new crop. The infection of the soil is caused by fungi: *Dematophora necatrix*, Hartig, *Armillaria Mellea*,[1] Quelet, *Roesleria hypogœa*, Thum et Pass.; by the *Anguillulides*, *Heterodera Schachtii*,[2] Schm, and *H radicicola*,[3] Gr, and insects, the larvæ of which take several years to accomplish their evolution, such as the *Elaterides*[4] (click beetles), cockchafers, etc. All these parasites multiply greatly, especially when they are omnivorous and not disturbed by rotations; they are, in themselves alone, capable of preventing a plant from producing normal crops. Carbon disulphide in large doses creates in the soil a sufficiently poisonous atmosphere to kill them, and so sterilize the ground being cropped. It has been shown that carbon disulphide only temporarily affects the bacteria useful to agriculture, and Wollny formulates the results obtained up to now as to the action of carbon disulphide thus —

(1) The introduction of carbon disulphide into arable land during the period of vegetation has the effect, according to the quantity applied, of either completely destroying vegetable life or of causing temporary trouble. (2) When the sulphide is applied several months before cultivating the soil, the fertility of the soil is greatly enhanced. This action of the sulphide extends, according to the quantity used, over one or more periods of vegetation, and it is followed, if manure be not employed, by an important decrease in the yield of the field treated. The lower organisms which play an active *rôle* in the decomposition of organic matter and in the formation of nitrates in the soil, as well as the bacteria of the radicular nodosities of the *Leguminosæ*, are not killed even by strong doses of carbon disulphide, their activity only receives a temporary check, to resume afterwards all its energy.

Use.—The method of application and the doses used play, in fact,

[1] ARMILLARIA MELLEA (tree-root rot)—This fungus (commonest and most widely distributed of British toad-stools) lives as a saprophyte and as a parasite, its mycelium penetrates into the living roots of very different species of trees and develops in the bark and in the exterior layers of wood; from the roots it gains the foot of the tree and there it produces yellowish-brown clusters of receptacles on the level of the ground. It attacks vines, apple-trees, mulberry-trees, fig-trees, on which it causes diseases which are confused with others under the general name of rot

[2] HETERODERA SCHACHTII (nematode of the beet).—This microscopic worm is met with on the roots of different plants, such as the cabbage, spinach, colza, but it commits its depredations especially on the beet. The larvæ of the nematodes prick the radicles of the beets with the dart with which they are furnished, and fix themselves by the head in the cellular tissue.

[3] HETERODERA RADICICOLA.—Nematode, which lives as a parasite on the roots of very different plants, but contrary to the nematode of the beet produces galls on the roots These galls shelter the worm during the whole of its development.

[4] ELATERIDES AGRIOTES—Wire-worms, click beetles, skipping beetles, skipjacks, spring beetles. Small coleoptera of 1 centimetre at the most elongated and flattened; several species are injurious to grain and other crops. The larvæ alone are injurious. They have a thin, elongated, cylindrical body, like that of a worm, their colour is yellowish, shining, their maximum size is about 2 centimetres (¾ inch) long, their skin is scaly, very hard, and difficult to crush. Their development is very long; it lasts five years.

a *rôle* of very great importance in the services which carbon disulphide might render in destroying the phylloxera of the vine. Monestier, Lautaud, and Ortoman concluded that carbon disulphide is not injurious, except in the liquid state, when it is brought into direct contact with the roots of plants, it is necessary therefore, so as to remedy this drawback, to inject the liquid at a certain distance from the plant in such a way that the vapours disengaged form around the roots an atmosphere sufficiently toxic to kill the parasites. With this end in view they recommended that the carbon disulphide be caused to act from below upwards by depositing this agent in holes pierced to a depth of 80 centimetres (31½ inches); although based on an excellent principle, the use of carbon disulphide too often caused the death of the vine, for the doses used, which varied from 150—375 grammes per stock, were too strong. Experiments by the Montpellier Agricultural Society, due to the initiative of the Viticultural Association of Libourne, led to a gradual decrease in the dose, which was definitely regulated to 12—20 grammes only per square metre, say 24—28 grammes per stock Dumas' researches showed that even 3 grammes per square metre ($\frac{1}{10}$ oz. per square yard) were sufficient to attain the object in view.

At the present time the utility of carbon disulphide is no longer in doubt; it has rendered, and renders, undoubted services, and its use has become universal. Its method of use varies according to the parasite to be destroyed. The best results are got when an atmosphere containing a dose poisonous to insects and their larvæ can be produced. This condition is easily realized underground, in granaries, hothouses, and under tents of impermeable cloth, with which small-sized trees may be covered. In these different cases liquid carbon disulphide is always used, and acts by evaporation. When an asphyxiating atmosphere has to be produced underground, the carbon disulphide is introduced to a certain depth by a soil injector, which is regulated for the desired dose. In soils favourable to the diffusion of gases, such as those which are not too compact nor too moist, the vapours of carbon disulphide, in a dose of 20 grammes (307 grains) spread within a radius of 30—35 centimetres (10—12 inches) around the spot where it has been poured. These vapours remain long enough in the soil for the toxic atmosphere to produce its effect. According to the parasites to be got rid of the dose is diminished or increased, and injected to a variable depth. There are cases where the roots of the vine descend so deeply that the carbon disulphide must be injected to 80 centimetres (31½ inches), whilst to kill the larvæ living a few centimetres from the surface, one does not go down more than 20 centimetres (7 8 inches). To use carbon disulphide it is therefore necessary (1) To ascertain the exact spot where the parasites to be killed are, first making a trench and making it at about 20 centimetres (7·8 inches) below the invaded zone. (2) To choose the moment when the soil is in such condition as to allow the diffusion of carbon disulphide vapours into the interior of the mass, whilst at the same time it places the greatest possible obstacles in the way of their loss. This moment varies with the nature of the soil to be treated. A clay soil, for instance, cannot realize favourable conditions when it is saturated with water, or when it is cracked by drought. On the contrary, a sandy soil, after a slight rain, is in favourable con-

dition. The most propitious moment is when the soil presents a certain interior mobility and a great enough density on the surface. In these conditions the vapour of carbon disulphide easily diffuses around the roots, and remains imprisoned by the hard surface, which forms a sort of envelope. Those advantageous conditions may be realized artificially by injecting carbon disulphide into a very dry soil and watering the surface soil, after having carefully plugged the holes. (3) Never to stir the soil after treatment, for the carbon disulphide, already very volatile, would, in certain instances, escape into the air without producing its effect, it is therefore necessary, so as to employ it with success, to maintain it as long as possible in the infected zone To attain this end recourse has been had to two preparations, which allow a less rapid evaporation of carbon disulphide.

Vaselinated Sulphide.—In 1874 Bouttin proposed a mixture of carbon disulphide and nut oil. Cubes of wood, soaked with sulphide and covered with silicate of soda have been tried but neither of these processes have given good results. Vaselinated sulphide was invented by Dr. A. Meunier and examined by Cazeneuve vaseline (petroleum jelly, known by this trade name) forms an emulsion with carbon disulphide and prevents it from evaporating rapidly. It was hoped, owing thereto, to lessen the chances of evaporation into the atmosphere and to prolong its action in the soil Mixtures were tried of equal parts of the two substances, or of 30 per cent of vaseline and 70 per cent. of carbon disulphide. It has been observed by Vermorel and Jossinet that the dose of 20 grammes of liquid carbon disulphide placed in each hole 35—40 centimetres round the vine suffices to kill the phylloxera, but when mixed with vaseline this quantity is not enough. However, if the holes be brought to within 10—15 centimetres of the stock, the conditions favourable to the action of this preparation are improved. Marion and Gastine conclude that there is no advantage in this mixture, since the dose of sulphide must be greater to give the same result. They further remark: If more than 50 per cent. of vaseline be incorporated in the carbon disulphide, the evaporation which is produced during injection is as great as when employed pure, and finally the vaseline retains about 15 per cent. of sulphide which it only cedes very slowly, and which remains without effect. Wooden cubes impregnated with sulphide as well as mixtures of carbon disulphide and heavy oils, gave no advantageous results, and the pure sulphide should be preferred to all these preparations. It is a great error to imagine that carbon disulphide must develop slowly to produce a salutary effect. For the action of the sulphide to be effective, what is required, above all, is to create almost instantaneously an atmosphere highly charged with poisonous vapours around the radicular system invaded by the parasites and to maintain it there as long as possible. To slacken the evaporation of the carbon disulphide is to remove from it one of its precious properties, that of its great diffusibility. A slower evaporation will not create an atmosphere sufficiently toxic to kill the parasites. A great number of volatile substances, very poisonous to the phylloxera and used in the same conditions as carbon disulphide, have never been able to equal it, as their diffusion in the soil was too slow. To avoid the loss of carbon disulphide in the usual treatment

with the injector, the use of gelatinized capsules containing a dose has been tried. These capsules are arranged in holes made with a soil-injector, and afterwards plugged. Under the action of the moisture of the soil the gelatine finally dissolves, the sulphide flows out into the soil and rapidly evaporates. The operator has thus a convenient time without fearing loss of the sulphide to plug the holes and to water the surface of the soil to imprison the vapour after the rupture of the capsules In spite of the apparent advantages of this process, it has had to be renounced in viticulture because the disengagement of sulphide was too irregular and not simultaneous in the zone treated. In horticulture these capsules are handy because they are easy to use and as they avoid the purchase of a soil injector. (4) To distribute uniformly the sulphide in all the soil to be treated. This is done by placing the holes at equal distances from each other, and by using instruments which enable equal doses of this substance to penetrate into the soil. Carbon disulphide may be injected into the soil during almost the whole year. However, it is less injurious to the plant if the operation be performed during the time vegetation is at rest. In any case, its use should be avoided during the flowering period and when the fruit approaches maturity.

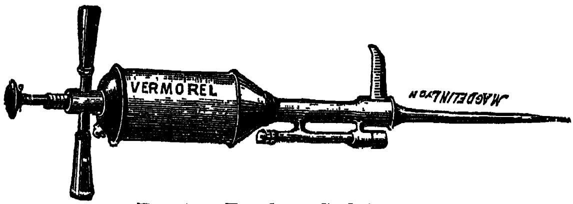

FIG. 7.—Excelsior Soil-Injector

Instruments Necessary for applying Carbon Disulphide.—The injector already mentioned must be placed in the first rank of instruments intended for this purpose. It is a sort of compression pump, intended to convey a known dose of carbon disulphide to a certain depth. The earlier type consisted of a reservoir in zinc or copper, intended to contain carbon disulphide. This instrument possessed, in its interior, the body of a pump in which a piston moves. Under the pressure of the latter a valve opened and closed the opening of a long channelled tube, which penetrates into the earth. An aperture near the sharp end lets the sulphide escape. In hard and gravelly soils the workman was preceded by an assistant, who pierced the holes with an iron crowbar. Vermorel later invented the *pal-Excelsior*, which differs from the foregoing by the fact that the valve is placed in a lateral tube by which it is possible to have a much stronger perforating tube. To regulate the quantity of carbon disulphide it suffices to give a longer or shorter course to the piston, by intercalating washers in the body of the pump. By this means the *pal-Excelsior* can be regulated at will for an output of 5, 6, 7, 8, 9, and 10 grammes of carbon disulphide at each injection. In actual sulphurization the injector is seized by the two handles, then sunk in the ground by the help of the pedal. By pressing on the rod of the piston the carbon disulphide is projected

into the soil, then the rod re-ascends of its own accord, under the action of an inside spring The injector is withdrawn from the soil, and an assistant rapidly fills up the hole with a wooden rod ending in a rounded piece of iron or lead. To hasten the operation, which ought to be done very rapidly, it is well to employ three workmen, and to possess two injectors A workman fills the container of the injector by a tap fixed on the barrel, whilst the second injects, and the third plugs the holes. In vineyards arranged for the work the injector is replaced by sulphide wagons or traction injectors, which do the work much more rapidly, and thus economize manual labour. The mechanism of these machines comprises a roll, acting like a pump, which after drawing the carbon disulphide into a reservoir, spreads it into a hollow traced by the sock of a plough, which immediately covers the hollow which has just been excavated.

In other appliances the organs of distribution of the carbon disulphide are fixed to some sort of plough. These machines are criticized for not depositing the sulphide deep enough in the soil. To secure a good distribution of the carbon disulphide through the layer to be disinfected, recourse is often had to 1 per cent. aqueous solutions. At that strength the carbon disulphide is not injurious to the plant, but perfectly capable of killing subterrannean parasites.

Disinfection in Closed Spaces.—CS_2 is used in granaries where food-stuffs are stored. It suffices in that case to spread on the floor a certain dose of carbon disulphide, after having closed all the vents in the place. A toxic atmosphere must contain 0·5 per cent. of carbon disulphide. When it is required to disinfect a small quantity of corn, it suffices to enclose the grain in a cask containing 0·5 per cent. of sulphide, and to keep the cask hermetically closed for twenty-four hours. The grain sometimes acquires a bitter taste after this treatment, but this is removed by stirring the grain with a shovel, or by passing it through the fanners. What is important to be pointed out is, that the grain suffers no alteration and retains its germinative and alimentary faculties. Carbon disulphide therefore presents real advantages over sulphurous acid employed in like conditions, the latter having the drawback, according to Balland, of removing from the gluten the special qualities which enable it to be used in bread-making (see p 63).

Destruction of Aerial Parasites.—When the plant attacked is of no great height it is covered with a tent of impermeable oil-cloth, or by a zinc bell, or better still, by half a barrel (petroleum), as is done in the treatment of vines by sulphurous acid. By this means an atmosphere containing vapours of carbon disulphide can be created around the tree, capable of rapidly destroying the parasites without injuring the plant, whilst, according to Ritter and Moritz, the phylloxera under its *gallicole* form and its winter egg, is killed in half an hour at a temperature of 20—30° C. (68—86° F.) in an atmosphere containing a sufficient dose of sulphide. The vine supports without suffering the action of this gas for twelve hours at 20° C. (68° F.). It is, however, to be observed that the longer the duration of the treatment, and the higher the temperature, the greater is the action of the sulphide on the plant. The dose of sulphide to use ought never to be greater than 0·5 to 1 per cent. For this purpose 50—100 grammes of sulphide

per cubic metre are placed in a cloche or in a flask hooked to a branch, or on the soil in a saucer. In hothouses the atmosphere must not contain more than 0·5 per cent of carbon disulphide. To destroy the larvæ of xylophages, such as the larvæ of the Saperdes, the grubs of Cossus,[1] and of Sesia, a poisonous atmosphere is formed in the burrows they make in the trunks of trees. To imprison the vapours it is necessary to close the burrows with some sort of mastic. This treatment is in no way prejudicial to the plant Where fumigation in an enclosed space is impracticable, recourse is had to pulverizations with soapy emulsions, made in the same way as those with a petroleum basis, and containing 2 per cent of sulphide, the limit of innocuity on the tender parts of the plant. In certain cases the invaded spots are plastered with the pure sulphide by means of the brush, and that chiefly when it is a case of the destruction of the woolly aphis (*Schizoneura lanigera*). The action of the sulphide employed in this way is not so perfect as in a hothouse, or under a cloche, its rapid evaporation not allowing of a sufficiently long action which thus often allows the parasite to escape death.

Use against Cryptogamic Diseases.—*Dematophora necatrix*, Hartig —Jean Dufour, Director of the Station Viticole de Lausanne, succeeded in arresting *Rhizoctinia* of the vine by applying carbon disulphide at the rate of 200 grammes per square metre (say about 7 oz. per 40 inches square), after having removed the diseased roots. According to this eminent observer carbon disulphide not only acts by destroying the mycelium of the fungus in a great measure, but it also imparts greater vitality to the vine. The latter, rendered more vigorous, resists afterwards the action of the fungus which may have escaped the destructive treatment Oberlin and Foex believed that the improvement in soils got by the use of the exterminating treatment against phylloxera is due chiefly to the destruction of the mycelium of injurious fungi which intervening crops are not capable of eliminating, because they can live, if need be, just as well as saprophytes as parasites on different plants To disinfect a vineyard it is advisable to proceed as follows: After having staked out the ground by metric divisions, two holes per metre 25—30 centimetres (10—12 inches) in depth are made with an injector and 100 grammes ($3\frac{1}{2}$ oz.) of carbon disulphide are injected into each. In compact soils four holes are made, each of which receives 50 grammes of sulphide. It is always well to water the ground after this operation, so as to maintain the carbon disulphide as long as possible in the soil. This treatment is generally carried out in winter, and the vines are replanted the following spring. Carbon disulphide is not applied against any other cryptogamic diseases, but it possesses, however, a certain action on the spores of fungi. Dr. Delacroix in his researches on the *Fusarium Dianthi* (P. et D.) observed that the conidia are killed after seven hours in an atmosphere saturated with carbon disulphide, and that the chlamydospores are destroyed after

[1] Cossus ligniperda (goat moth) —This bombyx lives three to five years as a grub which attacks indifferently weeping willows, poplars, elms, fruit trees, larches, and many other trees; it bores holes into these trees of the thickness of a finger which in multiplying form immense cavities on the trunk. The caterpillar is bright red in colour; it gives off a decided odour of musk.

twelve hours The spores of fungi resist the action of carbon disulphide much better than insects, but it is not impossible that the sulphide will yet find some applications for the destruction of certain fungi refractory to the action of the different cryptogamic bouillies.

Use against Anguillulideæ (Eelworms) —*Heterodera Schachtii* (nematode of beetroot)—Kuhn, who has principally studied this parasite, believes that the exhaustion of the soil in beet cultivation is not due, as is generally imagined, to the want of potash or other elements necessary to intensive cultivation, but exclusively to the exaggerated development of this eel. Rotations are powerless to destroy this parasite, because it lives quite as well on other plants Carbon disulphide was not recommended until 1877 by Aimé Girard, after he had discovered its surprising effects. In Germany, Hollrung also got good results by the use of this insecticide, provided it was used in a large dose, that is to say, of 1·8 metric tons per hectare (say 1584 lb per acre) spread in holes placed regularly 50 centimetres (20 inches) apart.

Heterodera radicicola, Greff. (root eelworm).—Dussuc recommends for the destruction of this eelworm the cultural treatment used against the phylloxera. The different nematoides that live on the roots of all these plants of large scale agriculture, and which neither deep cultivation nor rotations can destroy, contribute in great measure to create that peculiar state of soil known as *exhaustion*. In these conditions when their presence in very great number is recognized in a soil, it is well to have recourse to a complete disinfection of the soil, using heavy doses of carbon disulphide. This treatment will maintain the fields in good condition for several years, especially if care be taken not to convey thereon farmyard manure liable to contain eelworms

Use against Insects.—Insects the larvæ of which live at the expense of the roots may be destroyed by carbon disulphide used in the conditions indicated to destroy the phylloxera.

Melolontha vulgaris (cockchafer).—In carbon disulphide an infallible remedy has been found for the destruction of the larvæ of the cockchafer, the white worm, on condition that it be applied at the right time and intelligently. Falconnet and Treyre, who were the first to use this insecticide as far back as 1883, pointed out the absolute efficiency of this treatment. (U.S. investigators state that, though the fumes of carbon disulphide have a marked effect on *Melolontha*, provided that the concentration and time of exposure are sufficient, hydrocyanic acid gas and chloropicrin are more rapid and complete in their action.) There do not exist for this particular application of carbon disulphide precise data as to the depth to which the injection should be made. The white worm travels, in fact, constantly in the soil; it rises and descends according to the hygrometric condition of the soil, and the temperature In winter it buries itself at a depth where it cannot be reached by insecticides, in summer it ascends, on the contrary, into the superficial layers where disinfection cannot reach it, the tension of the vapour of carbon disulphide not being sufficient, and the larvæ often finding enough air to escape asphyxia. It is therefore necessary to seize the moment when the larvæ are about 30—40 centimetres (12—16 inches) from the surface of the soil, that is to say, about the month of October or November, when it descends, or in the month of

February, when it re-ascends into the surface layer to commence its ravages. So that the treatment may be followed by a complete result, it is necessary that carbon disulphide invade the whole zone of soil occupied by this dangerous larva; the treatment ought, therefore, to be preceded by trenching with the spade which should determine for the moment the spot occupied by the white worm. The injection is regulated in such a way that carbon disulphide is volatilized appreciably in that zone, which will be reached by working 5 centimetres further down It is useless to treat the soil during the period of the year the perfect insects appear, and which current language designs as beetle seasons, the laying being done in the month of June, the white worms, which are hatched a short time afterwards, do not yet cause appreciable damage, and moreover these young larvæ reside so near the surface soil that it would be difficult to attack them. The treatment is put off generally until the month of February of the second year, and the time chosen the moment the larvæ appear on the surface of the soil. The laying of the beetle occurring only once in three years, there is only one favourable period occurring in this interval. It only lasts a few months. It can be applied in market garden or in nurseries without entailing great expense. It has the advantage of killing at the same time rats, mice, moles, mole crickets, grey worms, and all the parasites which injure crops. Falconnet and Treyre have found that the dose of 10 grammes per square metre (154 grains per 40 inches square) is sufficient in orchards to kill the larvæ in the deep layers of the soil Vermorel and Couanon recommend a stronger dose, that is to say, 20—28 grammes per square metre ($\frac{3}{4}$ to 1 oz. per 40 inches square). To spread this insecticide use is made of a soil-injector, which is regulated to distribute 5 grammes (77 grains) at a time in holes placed 50 centimetres (20 inches) apart in every direction. But the number of holes and the dose vary according to the nature of the soil and the kind of crop. On nurseries planted with grafts, the maximum dose is 200 kilogrammes, say 4 cwt. per hectare (176 lb. per acre); in these the tool ought to be sunk 35 centimetres (say 14 inches) in the soil, so as to inject the carbon disulphide lower than the roots, and thus to avoid contact with the liquid sulphide. On a soil free from any crop the best moment to treat it is likewise in the middle of the month of February, and in general it may be said that injections ought always to be made fifteen days before planting, provided the soil is very dry. If carbon disulphide has to be employed in the months of May and June, whilst the white worm exercises its ravages in the upper layer of the soil, Vaucher advises to spread a dose of 50 grammes per square metre, in six to eight holes of 18—20 centimetres (7—8 inches) deep Gelatine capsules containing $2\frac{1}{2}$ grammes of sulphide render good service under these conditions. It is necessary carefully to avoid working the soil fifteen days at least both before and after the treatment.

Eumolpus vitis,[1] F. (Ecrivain).—Besides the very efficacious method

[1] EUMOLPUS VITIS, F (*Adoxus vitis*)—Chrysomelide 5 millimetres in length, elytron (wing shell), maroon red, corselet and head, black. The larvæ hatch about mid-June and pass the winter following in the subsoil where they feed on the vine roots In spring they turn into grubs The perfect insect hatches in the month of April or May It first attacks the leaves, drawing straight and angular furrows, then the grapes, on which it makes grooves, which hinders the development of the grape and prevents it from ripening.

which consists in shaking the branches above a special funnel, carbon disulphide, applied as in the case of the phylloxera, is capable of giving good results. It is applied at the rate of 200 kilogrammes per hectare. This treatment has succeeded perfectly in Hungary

Vesperus Xatarti.[1]—Olivier recommends destroying these insects by treatment with carbon disulphide, applied in the months of December and January. For that purpose, two or three holes are made 25 centimetres (10 inches) from each stock, and into each hole 7 grammes (¼ oz.) of carbon disulphide is poured

Euchlora vitis[2] (green vine beetle)—Marchal recommends carbon disulphide as very efficacious in destroying the larva of this beetle

Pentodon punctatus[3] (Pentodon ponctué).—Dussuc advises destroying the larva of this Coleoptera by carbon disulphide, and previously to disinfect soils intended to receive grafted plants where this insect is very abundant.

Lethrus cephalotus,[4] Fb. (big-headed lethrus).—Carbon disulphide, it appears, gives good results in the destruction of this Coleoptera; however, it is advisable to make weak injections, for these must be done very near the stock, the insect being always found hidden in the neighbourhood of the roots.

Oryctes nasicornis,[5] L (rhinoceros).—Carbon disulphide gets rid of them.

Melolontha Fullo (fuller beetle); *Rhizotrogus solstitialis* (St. John beetle).—To destroy these insects in infested regions the sulphide should be applied before planting.

Larvæ of the Elaterides (wire worm).—A great number may be destroyed in infested fields by laying down small pieces of apple as bait, which as soon as invaded are collected (see note, p. 8). But complete destruction is only possible with carbon disulphide, which, in the different tests made, has always given good results. T. Tozetti has used the sulphide with a dose of 300—400 kilogrammes per hectare (264—352 lb. per acre), or even at a dose of 100 kilogrammes per hectare (88 lb. per acre) in emulsion with 100 kilogrammes of 4 per cent. caustic potash and 15 kilogrammes (13·2 lb. per acre) fish oil. The result is not perfect, except after having renewed the treatment, the success of the first injections only being momentary.

[1] VESPERUS XATARTI —Greyish longicorn coleoptera, 2 centimetres in length. The female of this Coleoptera lays 200—500 eggs in the beginning of winter under the bark of vine stocks. This insect is spread chiefly over the north of Spain, and in France, in the departments of the Pyrénées-Orientales and Aude.

[2] EUCHLORA VITIS (*Anomala vitis*, green cockchafer of the vine). The female of this Coleoptera lays about thirty eggs in the soil round the stem; the larvæ appear in the beginning of the month of August.

[3] PENTODON PUNCTATUS —This Coleoptera, injurious to vines, much resembles the bousier Its larva, which when full grown is twice the size of the white-worm, lives in the soil to the detriment of the new plantations of grafted American vines, for which it has a marked preference, of which it gnaws the young wood for two to three years.

[4] LETHRUS CEPHALOTUS (big-headed lethrus).—The lethrus is injurious to vines. It is 2 centimetres long, its body is globular and black. The lethrus is chiefly met with in Russia and Austria-Hungary.

[5] ORYCTES NASICORNIS. *Rhinoceros.*—The larva of this large insect resembles an enormous white-worm. Generally it lives almost exclusively on decomposing vegetable matter, in melon beds, and in dung in gardens.

Brocchi, as well as Mohr, has obtained excellent results against *Agriotes sputator* by using capsules containing carbon disulphide The larvæ of the *Elaterides* are very hardy, and as they live mostly in the upper layers it is advisable to make holes 20 centimetres (7·8 inches deep) and run in a dose of 50 grammes of sulphide per metre, say 775 grains per 140 inches square It would be advisable to roll the ground before treatment to consolidate it and prevent the sulphide from evaporating too rapidly. Amongst the weevils there are several which can be destroyed by carbon disulphide.

Peritelus griseus [1]; *Othiorhynchus sulcatus*, Fb. (black vine weevil). —Muller advises to make three or four holes per square metre round the tree and to distribute therein by the injector a total dose of 25 grammes of carbon disulphide. Insects hidden underground should be exterminated at the end of May, and the larvæ during summer.

Othiorhynchus ligustici, L. (Liveche's weevil)—Treatment with carbon disulphide is most efficacious. *O. raucus*, Fb, and *O. picipes*, Fb (clay-coloured weevil), both injurious to fruit trees and vines, may be treated in the same way.

Bruchus Pisi,[2] L. (pea-beetle)—This weevil passes its entire evolution on the pea. Peas intended for sowing should be disinfected. Reh has observed that the treatment by carbon disulphide was in this case as efficacious as hot water. It suffices to treat peas for twenty-four hours in a closed vessel and to aerate them afterwards. This same process is applied to *Bruchus rufimans*, Schonh (haricot-weevil); to *Bruchus granarius*, Payk (bean-beetle), *Calandra*[3] *granaria*, L. (calender or wheat-weevil), *Calandra oryzæ*, L (rice calender), and *Anobium paniceum* (maize-weevil). The larvæ of these weevils live inside the grain and cause great ravages in granaries. The following processes have been used to exterminate them Spread on the floor of the infected granary 1 litre of carbon disulphide (35·2 fl oz), pile the grain in a heap on the drenched space, and cover it with a tent or a cloth. The grain may also be spread in a closed chamber, in a layer 20—30 centimetres deep and 1—2 litres of sulphide per ton of grain to be disinfected uniformly distributed thereon. The whole is covered with sacks, and the sulphide allowed to act for twenty-four to thirty-six hours. This method of disinfection has the drawback of being attended

[1] PERITELUS GRISEUS.—This little weevil nightly attacks in hundreds the buds of the vine and fruit trees It preferably hides during the day in the buds or in the soil at the foot of the vine.

[2] BRUCHUS.—Small, squat-shaped weevils which attack the different leguminous seeds, peas, lentils, beans, tares, haricots. Each of these is attacked by a special species of *Bruchus*, but always in the same way. The perfect insect lays its eggs in the spring in the pods as they are being formed. The larvæ penetrate into the seed; there is generally only one larva per seed except in beans and haricots, where there may be two. The seed develops in the usual way, for the larva gnaws the albumen whilst respecting the grain The seeds attacked are easily known by their light weight, for they float in water, or by the small opening through which the insect has made its exit.

[3] CALANDRA GRANARIA (wheat weevil)—Black Coleoptera 3—4 millimetres long, the head is prolonged by a lengthy rostrum The calandra passes the winter in the depressions of the floor; in the spring it gets into the heap of wheat, pierces a small hole in the groove of the grain and there lays a single egg The same weevil pierces a large number of grains until it has ceased laying

by certain fire risks, and that is why it is done far from dwellings In that case a cask is used, which is filled with grain, then the carbon disulphide is run in at the rate of 500 grammes (1·1 lb) per 100 kilogrammes (220 lb. of wheat) The cask must be closed, with its lid, so as to roll it, first, shortly after closing and then a second time, twelve to twenty-four hours afterwards. Nothing remains to be done but to empty the grain, which is perfectly disinfected (Pabst and Hollrung). The resultant bad taste does not last long, and it rapidly disappears if the grain is shovelled a few times, or passed through the fanners.

Hypera polygoni.—The larva of this weevil attaches itself to the stem of the poppy and forms a disease of that plant. Sorauer advises the application to the stems of a soap emulsion, containing a little carbon disulphide

Saperda carcharias,[1] L. (large poplar longicorn)—It is recommended to inject carbon disulphide into the burrows occupied by the larvæ and to stop the holes at the base of the trunk with mastic. The larvæ of *Lucanus cervus* [2] (stag-beetle) in old oaks are destroyed in the same way, as well as numerous capricorns, of which the following are the principal:—

Cerambyx heros,[3] F. (great capricorn injurious to oaks); *Cerambyx dilatatus*, Ratzeb. (maple capricorn); *Galeruca calmariensis* (elm galeruca).—The larvæ pass through their first stage of metamorphosis underground, in the neighbourhood of the trees, in the end of July, and the perfect insects pass the winter in the same spot. It is therefore at these two periods that it is possible to destroy them by injecting into the soil 50 grammes of carbon disulphide per square metre, spread all round the stock, in eight holes only 20 centimetres (7·8 inches) deep. Watering of the soil before the application facilitates the action of the sulphide on these insects lodged in the upper part of the soil. Carbon disulphide has also been employed with equal success against:—

Gryllotalpa vulgaris (Courtilière, Taupe, Grillon), (mole-cricket, churr-worm, eve churr, or earth crab).—Soils are rendered immune for ten years by carbon disulphide on condition, however, that there is co-operation between the different proprietors of the neighbouring

[1] SAPERDA CARCHARIAS (shagreen saperda).—Among the longicorn Coleoptera injurious to wood, the saperda is one of the most common. It is 27 millimetres in length, brownish-yellow colour, the elytra carry black projecting points which impart to them a shagreen appearance The larva of the saperda is one of the most dangerous to young poplar plantations. The trunks of certain poplars, less than twenty years old, are sometimes riddled with holes to such a pitch, that a slight gale suffices to cause them to fall SAPERDA POPULNEA (saperda of the poplar).—This saperda is only 10—12 millimetres in length; it is blackish-brown; the elytra are spotted with small yellow dots. The female lays its eggs in the branches of the poplar. The larva penetrates into the branch, and there bores a long hole.

[2] LUCANUS CERVUS (stag-beetle)—Large Coleoptera, 3 - 4 centimetres long, furnished with very highly developed deer-horn-shaped mandibles. The larvæ, the development of which takes four to five years, bore holes in the trunks of the oak, birch, and beech

[3] CERAMBYX HEROS (the great capricorn).—Black Coleoptera 5 centimetres long with two long antennæ which in the male are longer in the body. The larvæ which are very large attack the oak preferably; they take three years to become perfect insects and cause the death of the finest trees by the numerous and wide burrows which they bore in the trunk.

cultivated fields The sulphide is employed at the rate of 40 grammes per square metre if the soil is compact, and at the rate of 30 grammes only when the soil is light. The latter type of soil is always preferred by the insect. In Italy, near Nola, where mole-crickets have caused serious ravages for twenty years, carbon disulphide has been used over a great area, and has been recognized as an infallible insecticide. Janin advises gardeners to use capsules containing 3 grammes of sulphide, and to deposit them here and there in their burrows, and afterwards to water the soil It is preferable to make injections in the burrows, by making numerous holes, in the spring.

Tipula oleracea [1] (daddy longlegs), *Tipula pratensis* (the spotted garden gnat).—Marechal got good results by injecting carbon disulphide To free a lawn from the larvæ of these insects 20 grammes of carbon disulphide should be spread in three holes per square metre, the grass trenched after a few days and sown with the seed. There may be destroyed in the same way the *Tipula crocata* and the *Tipula melanocera*, injurious to young plantations of *Abies balsamea* and of *Pinus sylvestris*.

Spilographa cerasi,[2] F. (cherry spilograph, cherry fly)—Besides the process which consists in collecting all the wormy cherries, Taschenberg recommends as an excellent means of destruction, to bore numerous holes, in the month of July, of 10 centimetres (4 inches) in depth, around the cherry trees and to run in a little carbon disulphide, to stop them afterwards, and water the soil. The soil under the tree may also be watered with a solution containing 1 part in 1000 of carbon disulphide.

Vespa vulgaris (common wasp), *Vespa crabo*.—To destroy these hymenoptera 20 grammes, say $\frac{3}{4}$ oz. by weight, of carbon disulphide is run into their nest during the night, and the orifice plugged.

Agrotis segetum, W. V. (common dart moth).—The grub of this moth is known as the grey worm. Coste-Floret has observed that the French vine, which regularly undergoes antiphylloxeric treatment, does not suffer from grey worm, whilst American vines, which are not treated with carbon disulphide, suffer much. The grubs of the following insects may also be combated by carbon disulphide, using the same process:—

Agrotis exclamationis [3] (heart and dart moth), *Agrotis Tritici*,[4] *Agrotis Ravida*, W. V., *Agrotis nigricans*, L, and *Agrotis corticea*, all injurious

[1] TIPULA OLERACEA (meadow tipula). TIPULA PRATENSIS (garden tipula)—The tipulæ resemble large gnats with long legs; the body is grey, highly elongated. These large mosquitos lay their eggs in June in the soil. The larvæ (large grey grubs, known as leather jackets), which hatch in eight days, live underground, where they attack the radicles of kitchen garden plants and ornamental plants

[2] SPILOGRAPHA CERASI (cherry-fly).—This fly, 4 millimetres long, is brilliant black with a head and legs yellow and the wings crossed by four black bands; it appears at the end of May The female lays a single egg on each cherry, preferably on the *bigarreau* and the geans.

[3] AGROTIS EXCLAMATIONIS or NOCTUA EXCLAMATIONIS.—The heart and dart moth. Dark lilac caterpillar, three bright longitudinal lines. The caterpillar gnaws the neck of roots and kitchen garden plants, turnips, asparagus; in spring it is particularly injurious to vines, the buds of which it gnaws

[4] AGROTIS TRITICI. *Noctua of Wheat*—See AGROTIS SEGETUM (p 26)—Similar caterpillar also called *grey-worm*.

to crops *Agrotis vestigialis*, Hfu., injurious to pines and larches *Hespialis Humuli*, L. (the otter moth), the larvæ of which gnaws the large roots of the hop from the month of August to the month of April.

Cossus ligniperda, L. (goat moth).—Taschenberg recommends to make injections of carbon disulphide in the burrows as soon as the grub appears, and to close the orifices with mastic; the grub is asphyxiated without injuring the tree. Trees attacked interiorly by the grub of the following butterflies may be treated similarly:—

Zeuzera Æsculi (leopard moth of chestnut), *Sesia apiformis*, L., Hornet (wood leopard moth).

Phthorimœa operculella, Zell. All stages of the potato tuber moth can be killed in mature potatoes by fumigation with carbon disulphide at the rate of 2½ lb. per 100 cu. ft. injected at a 27 in. mercury vacuum. This treatment cannot be applied to new, immature potatoes, as the fumigation causes scorching.

Amongst the *Microlepidoptera* which may be combated by carbon disulphide, those injurious to stored grain may be quoted, such as:—

Sitotraga Cereallela, A. (grain alucite); *Tinea granella* (grain mite); *Asopia farinalis* (flour mite).—They are destroyed like the wheat weevil.

Cemiostoma scitella,[1] Zell.—Sirodot recommends to combat this grub and exterminate the butterfly to hook on to the tree a flask containing carbon disulphide. All the Lepidoptera, of which the larvæ are minute, may be destroyed in the same way, such as *Elachista*, *Nepticula*, *Incurvaria*, *Coleophora*, *Cosmopterix*, *Gracilaria*, etc.

Plant Lice.—According to a report of the Minister of Agriculture of the United States, all root lice, of which the phylloxera is the best known, may be destroyed by carbon disulphide injected into the soil, around the infected plant. Amongst these lice, which live on roots, the following are the most important. *Phylloxera*, Fonsc.; *Schizoneura*, Hart.; *Pemphigus*, Hart.; *Tychea*, Koch.; *Trama*, Heyd; *Rhizobius*, Burm. These lice, which, for the most part, do not live exclusively on the roots, become especially injurious because they wither the latter up by their perpetual suction, and so kill the tree.

Phylloxera vastatrix (phylloxera of the vine).—To destroy the phylloxera, either aerial or underground disinfection is used. The aerial disinfection of the winter egg of the phylloxera, under the form of "gallicole," is done by methods described further on. However, it may be carried out by means of carbon disulphide on grafts and buds from a contaminated region, because a sojourn of an hour in an atmosphere saturated with the vapour of this insecticide is sufficient to kill the phylloxera and its eggs. Buds and plants may be so disinfected.

Underground Disinfection.—This method of disinfection is the most important. It is, in fact, because it withers the roots of the vine that the phylloxera kills this plant and destroys entire vineyards. Amongst the numerous insecticides, proposed for the destruction of the phylloxera, carbon disulphide, and its derivatives, the sulpho-

[1] CEMIOSTOMA SCITELLA (black spots of the leaf of the pear).—Microlepidoptera, the caterpillar of which is minute, which is to say that it gnaws burrows between the two epidermes of the leaves of the pear. These spots become black.

carbonates, have alone given good results. According to the district, and also as circumstances may require, two distinct treatments may be applied.—

1. The extermination process, destroying all the insects of the vine and the plant itself.

2. The cropping process, only destroying a portion of the insects, and not injuring the vine, so that the latter, in spite of its parasites, may produce sufficient crops.

Extermination Treatment.—In districts far from invaded centres, where an invasion of the phylloxera is in its initial stage and shows itself in certain isolated spots, which threaten a whole vineyard, there must be no hesitation at the right moment to adopt the extermination treatment, which is capable of radically arresting the propagation of the insect, but it is necessary to sacrifice, at the same time, the attacked vines. This process, which is less and less used, since by the cropping treatment the plant may be maintained in a passable state of resistance, was in use, and even obligatory, in the borders of France, Switzerland, and Alsace-Lorraine, the vineyards of which, constantly threatened by destruction, were only preserved by these drastic measures The extermination treatment is as follows: As soon as the phylloxera makes its appearance in a vineyard, the vine stems are cut down level with the ground, over the whole surface infected; these stems are burned on the spot. Before pulling up the stocks, holes 60 centimetres (24 inches) deep, 50 centimetres (20 inches) apart, in all directions, are made in the soil, and 50—100 cubic centimetres ($1\frac{3}{4}$—$3\frac{1}{2}$ fl. oz.) of carbon disulphide poured into each hole, which is plugged. If the soil be dry it is slightly watered, so that there forms on the surface a slight crust, which prevents the too rapid evaporation of the insecticide into the air. Three years after this disinfection all the stocks with their roots are pulled up and burned on the spot, after drenching them with tar. Fifteen days afterwards two new applications are made with weaker doses; 50 cubic centimetres per hole then suffice. In Alsace-Lorraine, where this treatment was prescribed, it was forbidden to replant the vine for ten years. Since the researches of Oberlin and Dufour have cleared the minds of the authorities, the vine can be replanted the spring following the treatment. These vines are, moreover, of extraordinary vigour, and yield from the fourth year a better crop than that obtained in untreated vineyards. If the extinction treatment was capable of retarding the phylloxeric invasion for several years, it has never, on the other hand, prevented subsequent invasions, so that this very costly treatment has been abandoned.

Cropping Treatment.—Instead of destroying the vine by heavy doses of $2\frac{1}{2}$ tons to 3 tons of carbon disulphide per hectare (1 ton to 24 cwt. per acre), its sanitary condition is to-day improved by an annual disinfection of 200—250 kilogrammes per hectare (176—220 lb. per acre), accompanied by more abundant manuring; instead of losing the precious time required to form a vineyard, the attacked vines are maintained in a good state of production. There are some that stand this treatment for thirty years, and are in perfect health. In Mouillefert's opinion, neither the cropping treatment, even in big doses, nor the submersion, nor other methods, give anything but incomplete results.

Some insects always escape destruction because the distribution of a gas or a liquid through a layer of soil of unequal composition can never be perfect. If this treatment be not annual, it will be of no use, but annual treatment accomplishes perfectly the end in view, for it then annually frees the vine from the greater number of its parasites, and enables it each year to regenerate its atrophied roots, and to live, therefore, with its parasite without suffering too much from it. Every rational observer must therefore acknowledge that if this process be not perfect, and that plants grafted on vines immune to this insect have been the safeguard of the vine-grower, carbon disulphide has rendered great service by preserving the greater part of the French vines in a good state of production. The pure sulphide, or its solution in water may be used.

Use of Pure Carbon Disulphide.—So that the treatment with carbon disulphide may give the desired result, it must be used according to the rules established by numerous experiments, and formulated by our learned professors. The accidents and mishaps that befel certain vine-growers were due to working during bad periods, and on unfit soil. Dr. Colas formulated rules as follow for the use of carbon disulphide: (1) Treat the phylloxera as soon as it appears. (2) Treat the whole of the vines, and not the spots only (3). Apply carbon disulphide in doses of 18—20 grammes per square metre, say $\frac{2}{3}$ of an oz. (wt.) per square yard. (4) Make injections between the stocks so as to place each of them between four holes, avoiding touching the roots with the injector. (5) Sink the latter only 15—20 centimetres (6—8 inches) deep. (6) Take care to plug the holes immediately after the operation. (7) Always take care to let heavy soils, which retain water a long time, drain after heavy rains and thaws. (8) Avoid treatment at the two seasons of the year when the sap begins to move. (9) Cultivate and manure the vines treated in a suitable manner. (10) Avoid treatment when frost is feared.

These rules have not been appreciably altered up to now. To create around the vine an atmosphere uniformly charged with vapours of carbon disulphide, uniform doses must be made to penetrate into the soil at equal distances. An arrangement of holes as uniform as possible must be chosen, and the treatment applied uniformly over all the extent of ground to be disinfected. Not less than 20,000 holes per hectare (say 8000 holes per acre) must ever be made, nor less than 40,000 (16,000 per acre) in land only slightly permeable. A distance of 30—40 centimetres (12—16 inches) is generally kept from the foot of the vine, so as to avoid wounding the large roots. In many cases, however, deep injections can be made at 20 centimetres from the stock. The amount of sulphide injected per hole depends on the number of injections per square metre. At Libourne, for example, only 12 grammes is injected per hole, say 160 kilogrammes (352 lb.) per hectare (141 lb per acre), instead of the dose of 200 kilogrammes (440 lb.) per hectare (176 lb. per acre) usually employed in the Rhone, where the vines produce in consequence of this methodical treatment as beautiful crops as before the invasion of the phylloxera. The dose to use depends, moreover, on the depth of soil and the age of the vine. If it be desired to bathe all the root system in a toxic atmosphere,

three holes must be made 1·2 metre (4 feet) deep, the roots of certain vines being more than 1 metre (3·28 feet) in length. Cabanel and Degrully, however, advise not to go beyond a depth of 50 centimetres (say 20 inches). In compact soils 20 centimetres (7·8 inches) is enough. When holes are made in the immediate neighbourhood of the stock as the tendency is now, a depth of 8—10 centimetres (3—4 inches) is not exceeded. The greater number of vineyards is treated by the injector. In large vineyards, however, the plough is employed as follows. In vineyards where the lines are a metre (3·28 feet) apart, two turns of the plough are given between the lines. Each line of treatment is 25 centimetres (10 inches) from each row of stocks. In the case of vines planted at greater intervals care is taken to maintain the distance of 25 centimetres from the stocks for the first line, the others are 50—60 centimetres (20—24 inches) from each other, but it is best not to approach the rows of vines too closely, for at 5—10 centimetres (2—4 inches) they suffer from the injections. Sulphuretting ploughs were introduced with great enthusiasm, but they did not give the results anticipated. That is, because in spite of their ingenious arrangement, the carbon disulphide cannot be introduced to any depth, without meeting and wounding the roots. The great advantage of these improved instruments consists in the fact that a man and a horse can treat ½ hectare (1¼ acre) with them in a day. The work, moreover, is very uniform as regards distribution and dose, especially with intermittent jet drainers. The latter, especially, have the great advantage of greatly facilitating the diffusion of carbon disulphide which is projected with force, and which is divided almost instantaneously. The efficiency of the treatment by carbon disulphide depends especially on the nature of the soil, and Degrully is of opinion that there exists for each soil a propitious moment favourable to the uniform distribution of carbon disulphide, this moment should be observed and chosen by the vine-grower. In permeable or sandy soil, cracked or too dry, the carbon disulphide will escape without producing its effect. But in compact moist or clay soils it does not spread enough and remains concentrated around the holes, thus destroying a portion of the roots in their neighbourhood and remaining without effect on a great part of the soil affected. The treatment must therefore be deferred until the soil is neither too moist nor too cracked by the heat.

Although the painstaking observer will always be capable of utilizing the sulphide against the phylloxera in no matter what ground, its use is exclusively recommended in medium ground, neither too light nor too heavy, neither too moist nor too dry. Just as the treatment should never be applied after tillage, which by lightening the soil lets the sulphide evaporate too easily, it is necessary to wait fifteen days before trenching or working. The most favourable time for treatment depends, moreover, on the condition of the vine; although the latter does not suffer from this treatment when the dose is small, yet it is advisable to choose the time when the sap is at rest. October or November is preferably chosen for making injections; February and March are quite as favourable. So that the action of the sulphide be complete, the vine must be allowed to reconstitute its root system by giving it abundant manure, especially mineral. When the vine has been sul-

phuretted annually from the time of the invasion, it need not receive further care than what it usually gets

Use of Carbon Disulphide Dissolved in Water. The carbon disulphide used in the beginning of the phylloxeric invasion, having too often caused the death of the vine, it was thought that by dissolving the sulphide in water it would be less hurtful. A saturated solution, i e. containing 0 5—1·2 per cent of carbon disulphide, is perfectly capable of combating the phylloxera, it kills it in twenty-four hours. The advantages of this method are that it is perfectly harmless to the vine even when it is in full vegetation, and that it can secure a uniform distribution in the soil. According to Degrully, the action of these solutions is the more perfect the more permeable the soil. Under this form the sulphide acts quite as well as potassium sulphocarbonate and has the advantage of being much cheaper; 200 lb. of sulphocarbonate employed in the same conditions as 10 gallons of carbon disulphide, in 1 per cent. solution do not give so good a result. To prepare a solution of sulphide, Fafeur frères have designed an apparatus capable of spreading water on a layer of carbon disulphide, in a closed reservoir. A current of water flows through a pipe of suitable dimension drawn out to a point The pressure obtained by the drawing out and the speed of the current is exerted on the upper part of a receiver full of water and sulphide which, owing to its density, always occupies the bottom of the receiver. This pressure is transmitted to the receiver by two orifices. The solution is thus produced under pressure in a closed vessel by the junction in a pipe of two jets of sulphide and of water, the intensities of which are always proportional to each other. By opening the gauge taps the dose is regulated from 0·5 1·2 per cent. The sulphuretted water is carried by buckets or a long watering pipe into small holes specially dug round the stocks. These holes should be well made, horizontal, and separated from each other by mounds of earth so that the liquid is spread uniformly in the soil. Working on a large scale steam pumps carry the sulphuretted water several kilometres (kilometre = 0·625 mile) by means of a galvanized iron pipe. The average amount of sulphuretted water for each stock is 20 litres (4·4 gallons), and the solution contains 0·5 per cent. of sulphide in summer and 0·7—1 per cent. in winter. The soil should be returned to its place as soon as possible after treatment.

Insecticide Irrigations.—These examined and recommended by Duponchel represent the most improved and rational system. Underground irrigation, already very efficient in itself especially when manure is added to the water, appears to be a method of treatment that can be usefully applied in the treatment of the vine attacked by the phylloxera. But although the ordinary treatment enables the state of diseased vines to be improved, it could not in itself constitute a sufficient remedy to kill the phylloxera and annul the disastrous effects of that insect. Insecticide irrigations have a very salutary effect on vines and fulfil the end in view. Carbon disulphide cannot, in fact, suffice by itself alone to re-establish the health of a diseased vine during drought, or when root growth is stopped To attain this salutary effect it is necessary to follow up the injections of sulphide, which in destroying the phylloxera suppress the evil by an underground irrigation which

causes the effects to disappear by fortifying the roots and giving new vigour to the vine It is better to combine the two treatments in a single one and to apply simultaneously to the plant, along with the water carbon disulphide and the necessary manures. This method of diffusing the insecticide throughout the whole depth of the soil, in a dose which it is known cannot injure the plant, produces an excellent effect. The irrigations ought to penetrate 20—24 inches into the soil. They require 1000 cubic metres of water per hectare, say 100 kilogrammes (88 lb. per acre) of sulphide, which represents 30 cubic metres (6600 gallons) of sulphide vapour (2640 gallons per acre). A stronger dose would injure the vine, especially during the epoch of vegetation, which lasts eight months. Insecticide irrigation is differentiated from the sulphide treatment by the fact that the first can be applied in the spring, in summer, and in autumn without prejudice to the plant, whilst the latter can only be done during the repose of vegetation. The irrigation water is brought to the culminating point of the vineyard to be treated. At this point it is mixed with the carbon disulphide in a tank, called the bubbling tank, and arranged so that the water charges itself with carbon disulphide without being able to carry away with it what has not been dissolved The same bubbling apparatus used to dissolve the sulphide may serve for dissolving the manures, so that the water entrains them and distributes them throughout the whole extent of the diseased vineyard. To produce good results the irrigation should be underground and the surface of the soil should be maintained constantly dry and friable by tillage or by hand hoeing, carried out after watering, and renewed each time that rain has strongly packed the soil To secure good underground distribution it is necessary to lighten the soil by tillage and to open around each stock a small ordinary stripping basin. These basins are connected with each other so that they can be filled in succession If the tanks have only the slight slope required to ensure the flow of water without a gush, the water introduced into the basins will filter into the soil without moistening the surface layer. As soon as the liquid is completely imbibed, the holes are filled with dry earth and the soil is soon afterwards tilled and hoed. The large quantity of water which these irrigations require renders the treatment almost impossible. But when a spring with an output of a litre a second (13·2 gallons a minute) is available the quantity of water produced suffices to irrigate 10 hectares (25 acres). Underground insecticide irrigations, although useful in all cases, are particularly favourable in the hot countries of the South of France, where it is necessary to ameliorate the hygienic conditions of the vine by moisture to enable it to reconstitute its root system after being freed from the insect which caused the disease.

Schizoneura lanigera, Hausm. (woolly aphis).—The disinfection of the branches, as is done by applying various insecticides, is not enough, for there exist underground hot-beds of infection which reinfect the crown of the tree. Carbon disulphide, used in injections round the plant, forms an excellent means of destroying the aphis living on the roots. Taschenberg and Goethe have recommended the use of carbon disulphide to destroy the colonies existing above ground. They advise for this purpose the use of a stick, to the extremity of which a lump

of cotton-waste dipped in carbon disulphide is fixed The woolly aphis can thus be destroyed at all seasons without injuring the apples. The colonies must not be overlooked, and it is advisable to recommence the treatment some time after the first Targioni and Sorauer recommend soap emulsions for the same object, the first a 2 per cent. carbon disulphide one, and the second a 4 per cent. one. Gold's liquor, recommended for the destruction of the woolly aphis, consists of 20 grammes of [spirits of ?] turpentine, 20 grammes of carbon disulphide, and 60 grammes of curdled milk Amongst the underground ground lice that often occasion great damage are the—

Schizoneura grossulariæ, Schule, which sucks the roots of the gooseberry.

Aphis Persicæ niger (the peach tree aphis).—This aphis causes ravages in peach orchards in America.

Tychea phaseoli, Pass.—The presence of which, on the roots of haricots, cabbages, and potatoes, sometimes causes them to perish. All these insects may be combated like the phylloxera. The lice which sometimes damage certain plants are successfully combated when it is possible to cover the plant with an awning or a cloche (bell-shaped vessel) under which a few grammes of carbon disulphide are laid. According to Smith all the lice are killed in an hour. Even after twenty-four hours' treatment at the ordinary temperature the plant does not suffer. Soap emulsions, 2—4 per cent., have likewise been applied in a general way, but these latter, which sometimes succeed perfectly, may completely roast the leaves, chiefly those that have been wounded

Coccides (cochineals, kermes).—In a general way the *Coccides* resist carbon disulphide to a greater extent than the *Aphides*, but they do not resist a sulphuretted atmosphere. By destroying the coccis the fumagine (smut of fruit trees) is arrested.

Coccus vitis, L, syn. *Pulvinaria vitis* (red coccis of the vine); *Dactylopius vitis* (white coccis of the vine).- Targioni-Tozzetti and Pastre recommend carbon disulphide emulsions.

Diaspis pentagona, Targ.-Tozz (mulberry kermes). -Franceschini recommends for the disinfection of buds to place the branches before detaching them from the tree in an atmosphere of carbon disulphide. With this end in view, the end of the branch is placed in a tight cylinder, where it is left some hours in contact with a toxic atmosphere. This treatment whilst disinfecting the buds is not injurious to them.

Orange scale insects · (1) *Aspidiotus Limoni*, Sign; (2) *Mytilaspis flavescens*, Targ.-Tozz ; (3) *Chrysomphalus minor*. The first, especially injurious, in Italy induces the fumagine, the last two, imported from America, dot the organs attacked with small yellow spots. Hoffmann recommends spraying with carbon disulphide emulsions, containing 2 per cent. of soap and 2 per cent of sulphide. Belle advises the destruction of these parasites in greenhouses and pot plants by covering the latter with an awning, and producing a sulphuretted atmosphere, 120 grammes of sulphide sufficing per cubic metre.

Saperda candida, F. (round-headed apple-tree borer) is a serious pest of apples and quinces in some parts of Pennsylvania. The remedies suggested are cutting out the borer or killing it with wire and injecting

carbon disulphide into the holes, afterwards stopping the holes with clay or soap. Where infestation is severe, a wash of lime-sulphur sludge should be applied in the middle of May and again about mid-June as a repellent

Goat Moth—Injections into the holes bored in trees by the larva of the goat moth are recommended by the British Ministry of Agriculture

Platyedra (*Pectinophora*) *gossypiella* (pink bollworm)—In St. Vincent experiments were conducted to determine to what depth carbon disulphide would penetrate cotton seed meal and deal effectively with the pink bollworm. Under the conditions of the experiment, the fumigation was effective against the adult moths at a depth of 12 in., against larvæ at 8 in, and against pupæ and eggs at 6 in. A second fumigation would probably be advisable after an interval of from 7 to 10 days, as by that time transformation would have occurred of any eggs and pupæ not killed by the first fumigation Cotton seed meal could therefore be effectively fumigated in bags with a diameter of 12 in. In the case of cotton seed, the effective range of the fumigant might be greater, as the material is not so closely packed There are no indications in these experiments that *P. gossypiella* can breed or maintain itself in cotton-seed meal.

Mammals.—The rodents which cause damage, such as the mouse, field mouse, ground squirrel, rat, and even the mole, may be destroyed by pouring carbon disulphide into their burrows and stopping the orifices of their nests It takes 20 grammes (say $\frac{3}{4}$ oz.) for the *Mus sylvaticus*, L, Borghi, 10 grammes (say $\frac{1}{3}$ oz) for the ground squirrel (*Spermophilus citillus*, Bajor); for rats 60 grammes (say 2 oz.) are necessary The most radical method consists in steeping rags in carbon disulphide and in inserting them deeply into their holes, which are afterwards plugged with plaster, mortar, or a plug of hay coated with potters' clay.

CHAPTER IV

SULPHUROUS ACID—SULPHURIC ACID (OIL OF VITROL)—CHLORINE—HYDROCHLORIC ACID—NITRIC ACID

Sulphurous Acid, SO_2.—**Preparation.**—This gas is prepared on the large scale by the oxidation of sulphur. When sulphur is heated in contact with air this product burns and is converted into sulphurous acid. Pyrites, or sulphide of iron, which is roasted at a great heat, may also be used to obtain the same acid. That is the process most usually employed. The gas is led into a gasometer, where it is liquefied by cooling

Properties.—Sulphurous acid is colourless and very fluid It boils at 8° C. below zero, its density is 1·45. Sulphurous acid is not combustible. Its use is, therefore, attended with no risk of fire. Respired in large quantities it induces suffocation, but in small quantities it is not injurious to man.

Action of Sulphurous Acid on Plants.—All plants, without exception, suffer in an atmosphere of SO_2. The leaves absorb this gas, very much attracted by water, and hydrate it. Almost all the sulphurous acid is retained there, and they are the first to suffer. A very small quantity then passes into the wood of the plant. Under the influence of the solar radiation the hydrated sulphurous acid is transformed into sulphuric acid, with liberation of sulphur, according to Loew's equation :—

$$\underset{\text{Sulphurous acid}}{3H_2SO_3} = \underset{\text{Sulphuric acid}}{2H_2SO_4} + \underset{\text{Sulphur}}{S} + \underset{\text{Water}}{H_2O}$$

The numerous analyses made on dead plants, after the absorption of sulphurous acid, all, in fact, give abnormal quantities of sulphuric acid.

Wislicenus, who widened the question by very conclusive experiments, believes that sulphurous acid, absorbed by the plant, has no injurious action on the latter, except the plant be full in the light, and especially in full sunlight; in darkness the action is *nil*, although there is absorption of the gas, and in winter the action is very attenuated. According to the experiments, an atmosphere containing a proportion of $\frac{1}{100000}$ of its volume of sulphurous acid kills fir-trees (*sapins*) in about four weeks if they are in contact with this air in full daylight, but these same firs do not appear to suffer if the experiment be repeated in darkness, even if the atmosphere contain $\frac{1}{300000}$ of sulphurous acid. It is thus evident that sulphurous acid is only converted into sulphuric acid under the action of light, and it is the latter acid which is injurious

to plants Agreeing with Von Heine, Wislicenus concludes that sulphuric acid destroys the chlorophyll of the plant, and that it thus acts in a manner unfavourable to assimilation. Sulphuric acid dries the cell-walls and renders them impermeable. Only the tissues in contact with the fibro-vascular bundles remain fresh and green, whilst the others wither, brown, or bleach. In that lies the characteristic symptom of these poisonings. According to Von Heine, the transpiration of the poisoned leaves, the cell-walls of which have become impermeable, is less than that of healthy leaves. As the activity of transpiration expresses the production of matter, the leaf assimilates less, the plant remains stationary, and finally dies. The greater the amount of sulphurous acid absorbed, the more intense the sun, the greater the heat, and the drier the air, the more quickly are these symptoms produced. All leaves, however, do not absorb the same amount of sulphurous acid in the same atmosphere. With equal leaf-surface, those of conifers absorb much less of this gas than those of deciduous trees and herbaceous plants. It was believed that the gas being absorbed by the stomata of the leaf, the quantity retained would be proportional to their number, but experience has shown that it is not so, for leaves absorb this gas quite as well by their upper surface. The herbaceous plants are ranked, according to their sensitiveness to sulphurous acid, between the conifers and the deciduous trees. The leaves of the *Papilionaceæ* (pea tribe), potatoes, cereals, and meadow grass, commence to fade and to brown at their extremities after exposure of two hours in air containing $\frac{1}{10000}$ sulphurous acid; in an atmosphere containing only $\frac{1}{80000}$ of this gas desiccation does not occur until after fifteen to twenty hours. For leaves of deciduous trees to perish the air must contain $\frac{1}{10000}$ to $\frac{1}{20000}$ of sulphurous acid Conifers in general, and especially firs, do not support air containing more than $\frac{1}{10000}$ to $\frac{1}{20000}$ of this gas, especially in the neighbourhood of factories. This small quantity of sulphurous acid necessary to cause a pathological condition of the plant is the reason why each factory chimney must be regarded as a perpetual hot-bed of infection. The smoke from the combustion of coal contains on an average 0 01 to 0·02 of sulphurous acid gas. The danger is obviated if the smoke is sent into the air by chimneys measuring 20 metres, say 65 feet, in height The following, for example, shows the deterioration undergone by a field of oats situated near a coke factory One thousand seeds of normal oats ought to weigh, on an average, 25—29 grammes, 1000 grains in the sickly field only weighed 14·76 grammes Both the grain and the straw in this field were analysed, and in both instances a large amount of sulphuric acid was found. Such damage to crops is particularly intensified around chemical factories, chiefly sulphuric acid factories, where pyrites is roasted, and zinc factories, in which blende, zinc sulphide, is calcined. The deadly action of the sulphurous acid sent into the air by these factories manifests itself at great distances. Forests 5 kilometres, say 3¼ miles, away still suffer from their proximity. A zinc works calcining 50 tons of blende disengages 37,000 hectolitres (814,000 gallons) of sulphurous acid. It will be seen that this amount of toxic gas, if not utilized, may carry devastation to great distances. Many observations have been made on this point, and it is found that

near (such) factories the leaves of the fir (? spruce) fall, those of the pine and larch, more resistant, only brown at the point, and the trunk blackens, conifers, in general, do not resist long. Deciduous trees, fruit trees, among others, lose their leaves and do not produce fruit, because the sulphurous acid sterilizes their flowers. The cornfields are sickly, patchy, the brown-coloured ears contain no grain Haricots and cabbages are spotted white and suffer much. The dead leaves of the potato shrivel and blacken The meadows remain sickly and turn brown. These sickly plants all contained an abnormal dose of sulphuric acid. It is important to insist on these facts, so as to show the injurious action of sulphurous acid on plants. Knowing this fact it is an easier task to contradict the opinion generally held that sulphur acts on fungi by its conversion into sulphurous acid. If it were so our vineyards, instead of becoming more vigorous by sulphuring, would perish, since an infinitesimal quantity of acid suffices to roast plants, and fructification, instead of being stimulated as is the case, would be diminished.

Action on Fungi—It follows from observations made on plants that those which contain chlorophyll are more sensitive to the action of sulphurous acid than those deprived of it. Sulphurous acid cannot therefore be used to destroy fungi.

Action on Insects.—To stifle insects the air must be saturated with SO_2 Great care must therefore be taken in using this gas so as to avoid its deadly action on plants. The great delicacy of the operation renders it less and less popular, hence the clochage of the vine still in use in certain districts is gradually being replaced by scalding. The phylloxera does not persist for twenty-four hours in an atmosphere of this gas of 1 in 60 or 1 in 100. Mouillefert tested it in the soil against phylloxera but without result Moisture and the nature of the soil destroy its toxic properties

Use in Diseases Treated by SO_2 in the Open Air. *Gum Disease.*—Swingle and Webber who examined the action of different chemicals on this disease recommend to cure it, to clean the wounds and coat them with an 18 per cent. solution of SO_2.

Anthonomus Pyri,[1] Boh, *Anthonomus pomorum*.[1] These formidable destroyers may be removed in May by SO_2 fumigations (Poupinel). A dish of burning sulphur is moved about under the branches, or rags dipped in molten sulphur and then lit. The trees should not be fumigated with SO_2 when in blossom, as the flowers would be sterilized even if the contact was short and the acid in very small quantity.

[1] ANTHONOME OF THE APPLE-TREE. *Apple blossom weevil*, *Anthonomus pomorum*.—Length, 4 millimetres; colour, blackish-brown, with short, compact hairs forming a down, rostrum arched The adult insect lives the whole year at the expense of the apple leaves In the spring the female pierces a hole in the floral envelopes and deposits an egg in each flower bud until finished, laying thirty eggs at least After an incubation of five to eight days the larva is hatched and attaches itself forthwith to the stamens and pistils of the flower, thus destroying the essential organs of the latter The French gardeners call the browned buds cloves ANTHONOME OF THE CHERRY-TREE. *Anthonomus druparum*. Brown weevil of 5 millimetres which lays its eggs in the flower buds of cherry-trees. ANTHONOME OF THE PEAR-TREE. *Anthonomus Pyri*.—Weevil very similar to anthonome of the apple-tree, but it lays its eggs in the floral buds of the pear-tree before and not during winter. Its larva is what gardeners call the *winter-worm*.

Such fumigations also asphyxiate the grubs injurious to fruit trees, who know how to shelter themselves from spraying in the common nests which they spin. The most injurious are *Hyponomeuta Malinella*,[1] Zell (small ermine moth) and *Liparis chrysorrhœa* (brown tail moth). The grubs of these butterflies are only sensitive to fumes of SO_2 Dufour proved by trial that liquid SO_2 does not act on the grubs, and that even a 20 per cent. solution does not kill those of the *cochylis*.

Phylloxera vastatrix (vine phylloxera)—The phylloxera dies if exposed for twenty-four hours in an atmosphere containing 1 per cent. of SO_2 Hence it was thought the injection of SO_2 in the soil would destroy this injurious insect. A. Vigié recommended injections into the soil of a mixture of sulphur and sulphur fumes from the beginning of the phylloxera invasion. Henneguy remarked that when this treatment was applied in summer the spread of the disease was circumscribed, and although this process may be insufficient to free the vine entirely from its parasite, it destroys it to such an extent as even to allow the vine to thrive. Mouillefert examined the effect of SO_2 both as gas and in solution, as well as its different salts. He found that sulphites are quite powerless against the phylloxera. As to gaseous SO_2 it has no action on insects near the surface of the soil because this gas, with a great affinity for water, can never penetrate deep enough into the soil.

Mus Ratus, L (Rat)—M A. ter Mer advises the use of SO_2 to kill rats Rags are dipped in molten sulphur and petroleum, these are inserted into the burrows and lit. It requires about ½ lb. of sulphur per burrow. Taschenberg dissents; he found that this method failed, even if the gas is driven far into the burrows by means of special bellows.

Use of SO_2 in Closed Spaces.—The action of SO_2 is deadly to insects when the air is saturated with it. It is used especially in granaries against the Coleoptera and Lepidoptera injurious to the stored grain. It has also been used on small trees which can be covered with a tent or a cloche The last method is used especially to combat the *cochylis* of the vine.

Mycogone perniciosa [2] (mole disease of the mushroom bed), *Psalliota campestris*, L—Constantin and Dufour found that the spores of the *Mycogone* are killed by prolonged contact with SO_2. Mushrooms are in no way injured in an atmosphere containing this gas, even if the fumigation lasts twenty-four hours

Hops.—The preservation of stored hops is not always an easy matter. Disinfection with SO_2 does not always give the result expected. Behrens found that if SO_2 be incapable of killing the germs of the parasite which infest hops, it has a good effect on their quality, which it alters for the better. But it is chiefly against the invasion of Coleoptera into granaries and on the vine that SO_2 does good work. Amongst these insects are:—

Calandra granaria (or wheat-weevil)—As a curative method

[1] Hyponomeuta Malinella (small ermine moth), Hyponomeute of the Apple-Tree (tinea of the apple-tree)—Small imago the upper wings of which are white and covered with black spots

[2] Mycogone perniciosa (mole disease of the mushroom).—Mushrooms attacked by the mole grow in an irregular manner, swell, puff up, and become deformed to such a pitch as to be nothing but an irregular-shaped mass. This mass is covered in places by white spots and easily rots.

fumigation with SO_2 is used. The doors and windows of the granary are closed; sulphur is then ignited in a vessel placed on a support above a sheet of iron; 1500 grammes (3·3 lb.) of sulphur with 100 grammes (·22 lb) of saltpetre, suffice to disinfect a space of 50 cubic metres. The granary is left closed for twenty-four hours, then it is cleansed with a 2 per cent solution of corrosive sublimate The same process is used to destroy *Microlepidoptera*, the grubs of which ravage grain and flour granaries

Sitotraga cereallela (grain mite) —So that the SO_2 may penetrate well into the heap of wheat and kill all the grubs, Saint Ubery burns the sulphur in chafing dishes around which the grain is piled in heaps. To destroy butterflies the process used against the *Calander* gives good results. It suffices to place 1 inch to $1\frac{1}{2}$ inch of sulphured wick on slates laid on the heap of wheat, and to set fire to the wick. By analogy it was thought possible to destroy by the same gas the grubs which live in flour.

Asopia farinalis (flour mite).—The process recommended by Debray consists in burning in closed vessels 60 grammes of sulphur per cubic metre of flour; the method was regarded as obnoxious, the flour being rendered unfit for bread-making; Balland found this flour, whilst presenting no visible alteration, is appreciably altered in contact with sulphurous acid. The gluten has lost the valuable properties required in baking. It is recognized, in fact, that gluten gains in value by contact with alum, common salt, or blue vitrol, but that it cannot stand the action of sulphurous acid, SO_2, nor sulphuric acid, SO_3, nor sulphuretted hydrogen, SH_2. To destroy the tinea of grain, SO_2 must not be used, but insecticides like CS_2.

Tortrix or *Pyralis vitana* (pyralis of the vine). The grubs hibernating in the fissures of the bark of the vines can be killed by SO_2. The process employed in the South of France is known by the name of *clochage*, or sulphuring of the vine. After pruning the vine, each stock is covered by a zinc cloche, or half a petroleum barrel, under which 20—25 grammes of sulphur (say $\frac{3}{4}$ oz.) are burnt in a saucer. The SO_2 formed soon saturates the air under the cloche, and stifles the grubs sheltered in the interstices of the bark. The operation should not last longer than five to ten minutes, a more prolonged action having a deadly effect on the vine. A workman provided with twenty cloches can sulphur 1000 stocks per day. It is a very delicate operation, which may well be replaced by scalding, but its use is still widespread. So that it may succeed, it must not be done when the soil is noist, for the SO_2, instead of saturating the air, would be absorbed by the humidity in the soil. Clochage kills, at the same time as the pyralis, the vine coccis and the red spider. Reh found that all coccides shielded Homoptera, such as *Diaspis*, *Aspidiotes*, *Lecanium*, *Ceroplastes*, and coccides, which resist all insecticide spraying, may be destroyed by SO_2 fumes. The fruit trees are covered with a tent, and sulphur burnt therein, observing the same precautions as in the clochage of the vine.

Sulphuric Acid, H_2SO_4.—Sulphuric acid is obtained by passing a mixture of oxygen and sulphurous acid over spongy platinum or platinized abestos, heated to between 250° C. and 500° C. (482 932° F.). The vapours of SO_3 disengaged are led into a receiver surrounded by

a freezing mixture, where they condense. The process of manufacture usually adopted is to oxidise sulphurous acid by nitric acid vapours and to hydrate the vapours in lead chambers. The necessary SO_3 is obtained by "burning" iron pyrites in presence of an excess of air.

Properties.—The commerical acid of 66° B (168° Tw.) is a colourless, odorous, viscous, oily liquid of sp. gr 1·84. When water is mixed with the acid so much heat is developed that it may become dangerous if the water is added to the acid. Care must therefore be taken in diluting the acid with water to run the acid gently into the right amount of water with constant stirring. H_2SO_4 has a great affinity for water, and rapidly carbonizes organic matter

Action of Sulphuric Acid on Plants.—This acid exerts a corrosive action on the organs of the plants touched by it. A very small dose of this acid (even dilute) destroys the chlorophyll and degenerates the cell-walls, thus giving rise to a profound disturbance in the life of the plant.

Transpiration is less abundant, and that of itself diminishes or even abolishes completely the production of synthetic organic matter, the leaves brown, wither, fall, and the growth of the plant is visibly arrested. If the action of this acid on a plant be prolonged it soon dies, for the acid penetrates rapidly into the interior of the trunk, and the circulation of the sap is stopped. The same result occurs when a plant is in contact not only with the dilute acid but also with sublimed sulphur, which contains H_2SO_3, and under the influence of sunlight is converted into H_2SO_4 in the leaf itself.

Action of Sulphuric Acid on Fungi.—Plants not containing chlorophyll suffer much less than green plants in contact with H_2SO_4. However, owing to its hygroscopic nature, H_2SO_4 diluted to 0·5 per cent. exerts a corrosive action on fungi Laboratory trials made by dipping the spores into a drop of H_2SO_4 diluted to 0·5 per cent. show that such dilute acid destroys in most instances the vitality of the spores, provided that its action be sufficiently prolonged. In practice the 0·5 per cent. acid is quite inadequate to destroy the spores and mycelium of fungi, and stronger, sometimes even the 168° Tw. acid must be used. It will be easily seen that at that degree of concentration H_2SO_4 cannot be put in contact with the leaves of plants, and that it should be limited to applications on the trunk, or to disinfect certain seeds; in a wood it can only be used when there is no active plant growth. Under such conditions, plants do not appear to suffer from sulphuric acid treatment. When H_2SO_4 is used in combination with anti-cryptogamic metallic salts, its corrosive properties become valuable, because in attacking the protective membrane of the parasites it enables the poison to reach and destroy them more readily. In combination with green vitriol in the winter treatment of anthracnose of the vine, sulphuric acid is in current use, and of great service.

Use against Parasitic Fungi.—Sulphuric acid has been recommended for some years to wash seeds to free them from the spores of different fungi which might be brought on to cultivated land. Noel found that steeping in the 0·5 per cent acid sufficed to free seed-corn from anthracogenous parasites. He stirred up a hectolitre ($2\frac{3}{4}$ bushels) in 22 gallons of 0·5 per cent. acid, and sowed immediately afterwards.

This method has since been tested by specialists of high reputation and found deficient. Kuhn has shown that not only was the 0·5 per cent acid an anodyne for the spores, but had the drawback of being more injurious than sulphate of copper The injurious action of the acid on cereal grains does not make itself felt for some time Such seed-corn always retaining a little sulphuric acid cannot dry up completely and rot. This drawback may be avoided if care be taken to wash the seed in milk of lime immediately after steeping in the acid In fact, Boiret found that the spores of bunt were not completely destroyed after a twenty-four hours' steep in a 5 per cent acid, and that a 20 per cent. acid destroys the grains of wheat without killing the germs of the disease, even if steeped six hours therein All cereal grains are thus sensitive to the action of H_2SO_4, however, amongst the different species of wheat there are some which stand the acid better than others.

TABLE XI —*Effect of Steeping Seed Wheat for Different Lengths of Time in Dilute Sulphuric Acid on Germinative Capacity per cent.*

Sulphuric acid.	Duration	Golden drop.	Garter.
1 per cent	24	--	18
2 „	12	40	14
2 „	8	-	18
5 „	2	90	
5 „	1	92	60
Steeped in water	—	--	90

It follows that this acid does not possess the requisite properties to replace blue vitrol in the pickling of seed corn. The only seeds that can stand steeping in the acid are beet-seeds, which are surrounded by a protecting sheath which enables them to stand steeping in acid of 66° Bé. (168° Tw.) without their germinative capacity being diminished. This protecting sheath acts as a shelter to the germs of fungi and bacteria of the most diverse nature, such as *Phoma tabifica*, Prill. et Delacr.; *Pythium de Baryanum*, Hesse; *Bacillus mycoides*, *Bacillus butyricus*, *Proteus vulgaris* As soon as the radicle and cotyledons of the beet appear these fungi invade them, disturb the normal evolution and induce rot. Hiltner found that the 30 35° Bé. acid will destroy the germs of all these parasites. Linhart recommends 66° Bé. (168° Tw.) acid in which the seed is steeped half an hour, then washed ten minutes with a jet of water, then the seeds are dipped into milk of lime, and all that now remains to be done is to wash the seed for four hours in running water. The seeds so treated are in no wise injured. Their germinative capacity is increased; they spring up more rapidly and in larger quantity, and the disease germs are completely destroyed. For reference purposes a description is here given of the researches published on the resistance of spores of different fungi to dilute H_2SO_4. These laboratory trials were made by incorporating the spores of rust and of caries with a drop of dilute sulphuric acid, which after being a certain time in the acid were sown or examined by the microscope. Kuhn examined the action of sulphuric acid on the spores of the caries

of wheat, and he found that acid of the same strength is not capable of killing in the same time the different spores of caries A 5 per cent. acid acted thus :—

TABLE XII.—*Showing the Action of Dilute Sulphuric Acid of 0 5 per cent Strength on the Spores of Oats and Wheat*

Duration of action.	Oats	Wheat.
1 hour	Numerous living spores . .	Numerous living spores
6 hours	Living spores less numerous	,, ,,
8 ,,	Very few living spores .	,, ,,
10 ,,	All spores killed . . .	,, ,,

Wuthrich examined the action of different acids, compared with that of metallic salts, on the spores of—

Ustilago Carbo, Tul. (smut of grain crops).—In a 0 49 per cent. sulphuric acid all spores are killed after fifteen hours' action at 20—22° C. An acid of 0·049 greatly prevents the formation of zoospores, whilst acid of 0·049 per cent. has no longer any injurious action on the spores themselves. Herzberg examined the different rusts, and submitted their spores to the action of sulphuric acid of various strengths. The spores of *Ustilago Jensenii*, Rost , the smut of barley, were found to be the most resistant. To kill these spores they must be stepped fifteen hours in 3 per cent. acid, whilst those of the other *Ustilagineæ* are killed in much weaker acid. Moreover, the dilute acid has not the same action on the spores of the same species but of different ages, the mortal dose is given in the following table :—

TABLE XIII.—*Showing the Strength per cent. of Sulphuric Acid required to Kill the Spores by Smut of Barley, Oats, and Wheat of Different Ages.*

Species	Strength of sulphuric acid Per cent.	
	Old spores	Young spores.
Ustilago Jensenii, Rost . .	1—1 5	2—4
,, Avenæ, Rost . .	0·5—0 75	0 5 —0 75
,, perennans, Rost. .	0·1—0·25	0 25—0 5
,, hordei, Bref. . .	0·5—0 75	0 5 —0 75
,, tritici, Jens. . .	0·5—0 75	0·25—0 5
Circumambient temperature	15—18° C.	23° C.

Puccinia graminis (black stem rust, summer wheat mildew); *Puccinia Rubigo-vera*, DC. (orange leaf rust, spring rust of corn), *Puccinia coronata*, Corda (the crown rust of oats) —Wuthrich made a comparative examination of these three rusts, by submitting in turn their uredospores and their æcidiospores to the action of the more or less

dilute acid The time of steeping was fifteen hours, and the temperature 20—21° C. (68—69·8° F.) The uredospores resisted an acid ten times stronger than the æcidiospores, acid of 0·0019 per cent does not act on uredospores of 0·049 per cent , its action begins to make itself felt, but it is not until 4·9 per cent. acid is used that all vitality is removed from the spores. The æcidiospores are completely destroyed, and in the same conditions, by acid of 0·49 per cent. strength. The uredospores of the rust of cereals would appear to be the spores most resistant to the action of sulphuric acid, as they likewise are to anti-cryptogamic salts Hitchcock and Carleton have, however, prevented the uredospores from germinating, by steeping them for seventeen to nineteen hours in 0·1 per cent acid.

Claviceps purpurea, Tul. (ergot of rye).—The action of the acid on this disease was examined by Wuthrich, who found that 0·049 per cent. acid attentuated the germination of the conidia, but it required steeping for fifteen hours at 20—21° C (68—69 8° F.) in an acid of 0·49 per cent. to stop this germination completely. Wuthrich, who examined the action of the acid on the spores of *Phytophthora* and of *Peronospora*, found these latter much more sensitive than those of the black and red rust of cereals.

Phytophthora infestans,[1] de By. (potato disease).- Acid of 0·049 per cent. perceptibly diminishes the capacity of the conidia to form zoospores. It may be entirely arrested by destroying the conidia, by using 0·049 per cent acid for fifteen hours at 19—20° C. (66·2- 68° F.).

Peronospora viticola, de By. (vine mildew).—The conidia and the zoospores of this parasite behave like those of the *Phytophthora*; acid of 0·049 per cent. completely annihilates them in fifteen hours at 20° C. (68° F) In 0 0049 per cent acid the formation of zoospores may be restricted, and even suppressed, without the conidia being killed. The latter then germinate and produce directly a germinative tube. The deleterious action of sulphuric acid on the germs of mildew has caused it to be used for the winter treatment of vine stocks. Bouchard got good results by treating the vines in the spring after pruning with a 10 per cent acid. During three years the vines received no other treatment than the above, and the disease did not reappear. Acidulated solutions of green vitriol used everywhere against anthracnosis cause no injury to the stocks.

Gloeosporium ampelophagum, Sacc. (grape rot). To combat this disease the utility of the acid was found empirically. It is not, it must be understood, a question of treating this disease during the growing period, for sulphuric acid, or even the acid mixtures, would have a deplorable action on the stocks. The acid is used exclusively in winter to cauterize the spots hollowed out of the young wood, sorts of canker produced by the anthracnose containing spores which should be considered as hot-beds of infection. The remedy most generally used is a 50 per cent. green vitriol solution, but to intensify its action

[1] POTATO DISEASE. *Phytophthora infestans*--The fungus which is the cause of this disease attacks the leaves, the stems, and the tubers of the potato. The disease appears first on the leaves and the stems where it shows as brown spots which end by entirely covering them. In wet weather it spreads rapidly and may then destroy the plant

it is associated with sulphuric acid in the proportion of 1 to 2 per cent. Fifty kilogrammes, say 1 cwt., of green vitriol are taken, and 1 litre, say 4 lb., of sulphuric acid are poured on to it and the whole dissolved in 100 litres (22 gallons) of hot water. However, many vine-growers limit themselves to sulphuric acid and regard it as sufficient to circumscribe the disease. It is certain that it kills not only the spores of this disease but also those of the oidium. It is important to operate before budding-time, so as not to injure the growth. It is necessary to imbibe the stems, the runners, and all the wood, and even the eyes. The latter, owing to this treatment, blossom, it is true, some days later than non-treated vines, but this in many cases is an advantage. The coat may be applied with a brush or with a woollen rag.

Sphærella fragariæ, Sacc. (strawberry leaf blight).—Galloway recommends the following energetic treatment to destroy this disease: Spray the strawberries after gathering the crop with 2 per cent. acid, which kills both the old leaves and the spores of the parasite. The new leaves which spring up are perfectly healthy. Tyron found this treatment to give as good results as Bordeaux bouillie or alkaline sulphides.

Cuscuta [1] (Dodder).—Wagenblicher found that 0·5 per cent. acid killed dodder, but when used on fields of trefoil and lucerne against *Cuscuta Epithymum* the burning of the plant injured the crop. As a weed-killer on walks sulphuric acid is defective. The effect is immediate but the weeds soon sprung up as vigorously as ever. Finally, sulphuric acid has been prescribed against potato scab. Wilfarth, acting on the principle that ashes and lime induce this disease, tried to produce a contrary effect by spreading sulphuric acid on the fields. He therefore spread sulfarine, a mixture composed of magnesium sulphate and of 15 per cent. sulphuric acid. The results were decisive, as shown in the following table.—

TABLE XIV.—*Showing the Action of Different Doses of Sulfarine (kieserite) containing 15 per cent. of Sulphuric Acid on the Potato Disease.*

Dose.	Crop.	Per cent. diseased.
Blank	76 potatoes of which	80 diseased
2 kg. of sulfarine per m.^{2}	77 " "	60 "
7 " "	$76\frac{1}{2}$ " "	40 "
10 " "	73 " "	25 "
14 " "	73 " "	20 "
18 " "	65 " "	10 "
30 " "	$50\frac{1}{2}$ " "	5 "

The disease is, in fact, considerably diminished by this treatment, but the dose of 14 kilogrammes of sulfarine per square metre must not be exceeded, for there would be the risk of too small a crop which would be as great an evil.

[1] CUSCUTA EPITHYMUM (dodder of trefoil and lucerne).—These plants, which are deprived of roots and of chlorophyll, are essentially parasites of other plants from which they draw nourishment by numerous suckers.

Use of Sulphuric Acid against Insects and Worms.—*Tylenchus tritica*[1] [Bastian] (eel-worm of wheat).—This is a microscopic worm which causes the blight known in France as Nielle de Froment [and in Great Britain as "Ear Cockles," "Purples," "False Ergot," "Galls of Wheat Eel-worms"]. Davaine recommended steeping the affected grain in 0·5 per cent. sulphuric acid for twenty-four hours, but this method has the drawback of injuring the grain.

Tortrix vitana (pyralis of the vine).—The winter treatment against anthracnose of the vine by sulphuric acid, not only destroys the spores of the most formidable cryptogamic parasites, but according to Debray it also destroys the grubs of this butterfly which pass the winter in the interstices of the bark. According to the same observer the vine cochineal *Dactylopius vitis*, which passes the winter fixed against the wood, may be destroyed by spraying with 10 per cent. acid after the fall of the leaf. The acid employed under like conditions to destroy the *Schizoneura lanigera*, Haus, did not give the result expected. To kill *wasps* it suffices to pour 10—20 per cent. acid into the nest.

Chlorine, Cl_2.—Chlorine is an element widely distributed in nature in combination with certain metals—sodium, potassium, magnesium.

Preparation.—By the action of aqueous hydrochloric acid on manganese dioxide, or by the electrolysis of sodium chloride in solution.

Use.—This gas, of some use to kill fungi, is so poisonous to plants that its use is limited to saprophytic fungi, such as—

Merulius lacrymans,[2] Schm. (dry rot of wood).—As a remedy chlorine is the subject of a German patent, D.R.-P. 76877, according to which good results are obtained by piercing boards with holes into which chlorine is introduced; these holes are then stopped up hermetically.

Hydrochloric Acid, HCl.—**Preparation.**—The industrial preparation of this acid is subsidiary to the manufacture of sulphate of soda, intended for the production of soda ash. It is produced by decomposing common salt by sulphuric acid.

$$\underset{\text{Sodium chloride.}}{2NaCl} + \underset{\text{Sulphuric acid.}}{H_2SO_4} = \underset{\text{Sodium sulphate.}}{Na_2SO_4} + \underset{\text{Hydrochloric acid.}}{2HCl}$$

The salt is introduced into capacious cast-iron cylinders, luted with clay, and then sulphuric acid is run on to it. The hydrochloric acid which escapes is dissolved in earthen carboys containing water. Commercial HCl marks 22° by Baumé's hydrometer.

Use.—The searching examinations which have been made into the action of this acid on fungi have shown that its use is not advisable, because its action on plants is deadly. Bolley, in 1894, tried to use

[1] TYLENCHUS TRITICA ("ear cockles," "purples," "false ergot," galls of wheat, eel-worms of wheat).—The eel-worm of wheat is a very small filiform worm with a smooth tegument which twists its body like an eel, hence the name given to it; length 3 millimetres. The ears attacked in place of ordinary grain have small, rounded, blackish grains like smutty grains.

[2] MERULIUS LACRYMANS (dry rot).—This fungus, allied to the Polypora, is the most dreadful destroyer of building timber. It chiefly attacks resinous woods and produces the dry rot of pine timber and pitch-pine.

the anticryptogamic properties of hydrochloric acid against potato scab. The germs of this disease are killed, it is true, by steeping from five to twenty-four hours in a 2 per cent. solution of this acid, but the eyes of the potato suffer so badly that this method cannot be advantageously used Wuthrich, in a research published in 1892 on the action of metallic salts and acids on the spores of different fungi, proved that the amount of this acid required to prevent the germination of spores compared with that of sulphuric acid used is proportional to their chemical equivalents. Thus a solution of 0·0036 of HCl has the same anticryptogamic effect as a solution of 0·0049 per cent. of H_2SO_4. A solution of HCl of 0·0036 per cent of sulphuric acid prevents germination of the conidia and zoospores of *Phytophthora infestans*, de By., the conidia and the zoospores of *Peronospora viticola*, de By.; the spores of *Ustilago carbo*, Tul. But to prevent the germination of the uredospores of *Puccinia graminis*, Pers, acid of 0·036 per cent is required. Hydrochloric acid can replace sulphuric acid wherever the latter has given good results, if the plant be not unfortunately as sensitive as the spores of fungi

Action of Chlorine and Hydrochloric Acid on Plants.—Hydrochloric acid and bleaching-powder factories discharge chlorine and hydrochloric acid vapours into the air. The injurious effect of this gas makes itself felt sometimes two miles from the factory, a radius within which it kills plants This gas is even more poisonous than sulphurous acid itself, deciduous trees suffer as well as evergreens. The pathological condition of the plant attacked is distinguished by the brown border which forms on the leaves; then they are covered with brown spots. The needles of spruce fir trees become yellow at the point, dry up, and drop off. The analysis of the dry substance of the diseased plant twenty-five minutes distant from these factories, according to Konig, Steffeck, and Heine, gave the following results.—

TABLE XV.—*Showing the Effect on the Chlorine Content of Forest Timber of Proximity to a Hydrochloric Acid Works.*

Tree.	Condition.	Per cent. chlorine.	Increase in chlorine per cent
Oak	Healthy	0 081	
	Sickly	0 191	135·8
Beech . . .	Healthy	0 211	
	Sickly	0 311	71 14
Larch . . .	Healthy	0 279	
	Sickly	0 767	174 91
Spruce . .	Healthy	0 101	
	Sickly	0 132	30 69
Hazel . . .	Healthy	0·178	
	Sickly	0 516	189·88

These analyses show that the disease is produced by the absorption of chlorine and hydrochloric acid.

7

Nitric Acid.—Preparation.—The commercial acid is prepared by introducing into a cast-iron pan 330 kilogrammes (726 lb) of nitrate of soda and 420 kilogrammes (964 lb) of sulphuric acid of 62° Baumé; the lid is luted with clay and heated. The nitric acid vapours disengage through an earthen pipe, condense in big carboys, also of earthenware, placed one after the other, and each containing a little water. There are thus obtained 440 kilogrammes (968 lb.) of nitric acid of 36° Baumé Nitric acid is also now obtained in connection with processes for the fixation of atmospheric nitrogen.

Properties.—Nitric acid is a colourless liquid, sometimes yellow from the presence of nitrous acid. Its density is 1·52, its boiling-point is 86° C. It is very corrosive; in contact with organic matters it first produces nitrated compounds, then an oxidation which proceeds so far as destruction. It is quite as dangerous as sulphuric acid, and should be handled with many precautions.

Action of Nitric Acid on Plants.—The following are the results of the examination of nitric acids on plants: 0·05 gramme of this acid in a cubic metre of air produces poisonous effects on plants analogous to those produced by sulphurous acid, spots and brown borders on the leaves; yellow points on the needles of the conifers. The normal dose of nitric acid in the air is 0·00003 per cubic metre; it therefore requires a dose almost 2000 times stronger to produce pathological symptoms in the plant such as occur in the neighbourhood of factories which allow the vapour of these acids to escape.

Use.—Nitric acid is not only corrosive but poisonous to insects. This latter property is manifested, more especially, in organic compounds containing one or more nitro groups. Nitric acid, like sulphuric acid, has been recommended especially to combat insects in winter. Its action on fungi is especially injurious. Hitchcock and Carleton found that the uredospores of *Puccinia coronata*, Corda (crown rust of oats) are killed in twenty-four to twenty-six hours in nitric acid of 0·68 per cent., but an acid of 0 068 per cent. has no action on these spores.

The spores of *Phytophthora* and *Peronospora*, according to present knowledge, are destroyed by an acid of about 0·05 per cent. Nitric acid is not used to combat fungoid parasites except *black rot*, although it has been tried against several other cryptogams.

Guignardia Bidwelli, Viala et Ravaz (black rot).[1] Viala proposed to replace sulphuric acid in the winter treatment of the vine by nitric acid, which destroys the spores of this fungus. Against *insects* Lemoine recommended for the treatment of the phylloxera the coating of the stems with a mixture consisting of 1 kilogramme of nitric acid of 60 per cent., 2 grammes of spirits of turpentine, and 4 grammes of chrome yellow, the whole diluted in 5 litres of water. Examined by the commission who investigated the chemical products proposed to combat this insect the above mixture was pronounced defective.

[1] Black Rot of the Grape. *Guignardia Bidwelli*.—This disease is due to the parasitism of a Sphæriaceæ which in succession shows *conidia* fruit and *asci* fruit. On the stalks of the leaves black rot shows itself by reddish, more or less circular, well-defined spots. These spots, small at first, become larger and finally run into large black spots consisting of conidia fruits. These same spots are formed on the branches, on the cluster of grapes and on the grapes themselves.

At the present time it is recognized that nitric acid is very injurious to grubs and may be used wherever these are not on the vegetative part of the plant. By this method the grubs of the *Tortrix vitana* (pyralis of the vine) and the *Cochylis ambignella*, Hubn. (cochylis of the vine), which pass the winter in the fissures of the bark of the stem, may be destroyed.

Although Dufour's experiments, which could not destroy the grubs of the *cochylis* by steeping them for some seconds in 50 per cent. nitric acid, do not speak in favour of the insecticide action of this acid, the results obtained in actual practice have been very favourable. Sourdon and Castel, as well as Debray, have recommended for the winter treatment of the vine the use of commercial nitric acid diluted with six times its weight of water. After having barked the vine by Sabaté's iron glove, the eyes, the runners, and the body of the stem are coated with nitric acid. The method may be applied in all weathers, and its efficacy is almost always absolute. Debray is of opinion that nitric acid may replace *ebouillantage*, "scalding," which is a complicated method, and often inapplicable. Like the latter, it frees the vine from all cryptogamic parasites, and from all insects which seek a refuge in winter in the corners of the bark. Barbut's observations which induced him to affirm that 10 per cent. nitric acid only kills 50 per cent. of *pyralis* and 40 per cent. of *cochylis*, that the chrysales of *pyralis* can stand steeping in that acid for several hours without injury, and that treatment by nitric acid retards, moreover, the growth of the vine, in no way diminishes the good results obtained in actual practice, and the success of the winter treatment of the vine by nitric acid.

CHAPTER V

PHOSPHORUS—PHOSPHORETTED HYDROGEN—ARSENIOUS ACID—WHITE ARSENIC—ARSENIC ACID

Phosphorus.—Preparation.—Phosphorus does not occur in nature in the free state, but as phosphoric acid combined with various metallic oxides, lime, magnesia, soda, etc. In the industrial manufacture bones form the raw material.

Properties.—Phosphorus, insoluble in water and alcohol, dissolves in carbon disulphide. It is highly combustible. It oxidizes in the air at the ordinary temperature but does not ignite below 60° C (140° F.). It melts at 44° C. (111·2° F.) It is preserved under water Phosphorus is a violent poison which, when absorbed even in very small doses, induces vomiting and epigastric pains. It may act if it continue to be absorbed on the nervous system, which it depresses, and by paralysing the heart's action, it rapidly causes death. The intensity of the action of phosphorus depends on the form under which it is ingested; dissolved in oil, for example, it is much more poisonous than when in solution in other solvents, because in this form it is precipitated less easily in the aqueous juices of the stomach.

Use.—Phosphorus is as violent a poison for mammals as for insects. It is used everywhere where pastes can be used to destroy noxious animals. To prepare these pastes 50 oz. of boiling water are run into a porcelain mortar, then 2 oz. of phosphorus which soon melt therein; 40 oz. of flour are then added whilst stirring with a wooden spatula. When the mixture is almost cold 40 oz. of molten tallow still tepid are run in and 20 oz. of sugar. This paste may be used indifferently against rodents and certain injurious insects. The *Murides*, such as *Arvicola* (field mice), *Mus musculus* (domestic mouse), *M. agrarius* (field mouse), *M. ratus* (ordinary rat), *M. decumanus* (Surmulot rat), are destroyed by the phosphorus pastes, the preparation of which is given above. Mohr adds a little glycerine which preserves them longer in the air. With this poisonous paste slices of toasted bread are coated which the rodents eat without suspicion. According to Crampe it suffices to prepare a paste of boiled flour which is cooled to 43° C. (109·4° F.) before mixing in the phosphorus; pieces of straw are then dipped into the paste and laid in the burrow or in the run of the rodents. The latter in trying to remove them or in walking on them get daubed with pieces of paste on the hair, and are poisoned by licking themselves.

Amongst the insects killed by phosphorus are: *Periplaneta orientalis* (cockroach). This insect does great damage in hothouses by

gnawing orchid roots. Paste pills made from honey and phosphorus and laid on the pot of the plant attacked rapidly destroy the insect.

Gryllotalpa vulgaris (mole-cricket).—Elias Hugo destroys it by laying poisoned pastes of maize, starch, water, and phosphorus in the burrows and stopping up the orifices The mole-crickets disappear in twenty-four hours.

Formica (ants).—To poison ants Debray introduces phosphorus paste made from molasses and phosphorus. The orifices of the nest are then stopped.

Phosphoretted Hydrogen, PH_3.—**Preparation.**—(1) By the action of phosphorus on caustic alkalies or the hydroxides of the alkaline earths in presence of water and under the influence of heat (2) By decomposition of calcium phosphide by water alone or by hydrochloric acid.

Properties.—Phosphoretted hydrogen is a colourless gas with a strong smell, resembling rotten fish, inflaming at 60° C. (140° F.). It is poisonous, and acts especially by depriving the hæmoglobin of the blood of the oxygen fixed therein.

Use.—Phosphoretted hydrogen is recommended for combating the phylloxera. Mouillefert showed this gas to be five times more poisonous than prussic acid. An atmosphere containing 0 5 per cent. of phosphoretted hydrogen is very injurious to the phylloxeras, but the latter are not destroyed until after they have been fourteen hours in an atmosphere containing 1 per cent. of this gas. Experiments on the large scale have given variable results; those of Mouillefert, a negative one; those of Rosler, a perfect one. The former wrought thus: 20 grammes (310 grains) of phosphide were laid in three holes of 50—60 centimetres (20—24 inches) in depth, at equal distances round a stock, and then closed. The moisture and carbonic acid in the soil decomposed the calcium phosphide. Rosler, on the other hand, recommends the digging of holes around the stock, and to lay therein several layers of quicklime, on which a small piece of phosphorus is placed. The holes, filled up, are covered with water and then stopped with clay. Rosler recommends this treatment as efficacious, and without any injurious effect on the vine treated; it is done in the spring. Mouillefert ascribes the bad result of his experiments to the rapid oxidation which goes on in the soil, and to the feeble diffusion of phosphoretted hydrogen, which is less rapid than carbon disulphide.

Arsenious Acid, As_2O_3.—Arsenious acid, or arsenic, is obtained, commercially, by roasting arseniferous minerals, the arsenides, and sulpharsenides of nickel, cobalt, and iron, in capacious muffles, of refractory material, round which the flame from the fire circulates.

$$2FeAsS + 3O = 2FeS + As_2O_3.$$

The arsenious anhydride given off is led into cold, superimposed chambers, where it condenses as a white crystalline powder. It is removed by raking it out and purified by distilling it in wrought-iron vessels.

Properties.—White arsenic is a white or colourless, inodorous solid;

recently fused, it forms a vitreous, transparent, amorphous mass. White arsenic only dissolves at 13° C. in water, in the ratio of 1·2—1·3 per cent., whilst the vitreous acid dissolves in the ratio of 4 per cent. Its taste is at first faint, then bitter and nauseous. Arsenious acid is a violent poison for all animals, and in a dose of 1 decigramme, say $1\frac{1}{2}$ grains, kills man. It is a violent escharotic of the mucous membrane, and of all the tissues in general, which it inflames, and rapidly destroys. Absorbed by the digestive channels, it gives rise to gastro-intestinal symptoms, which are often followed by paralysis. In very small doses it is a powerful stimulant, which encourages growth. This property causes it to be much used in medicine. Arsenic is as poisonous to plants as to animals It burns the leaves Arsenites soluble in water are the more active the greater their solubility; those which are insoluble in water consequently have no injurious action on plants.

Herbaceous plants die when they are watered with a 0·5 per cent. solution. Deciduous trees are also very sensitive to the action of arsenic To destroy certain insects, a solution of 200 grammes in 100 litres (2 lb. per 100 gallons) were tried, but even in that proportion the arsenic is still too prejudicial to the leaves.

TABLE XVI.—*Showing Sensitiveness of Leaves of Various Fruit Trees to Solutions of Arsenious Acid of Various Strengths.*

Name of tree.	Grammes As_2O_3 per 100 litres [1]	Effect on leaves.	Name of tree.	Grammes As_2O_3 per 100 litres.[1]	Effect on leaves.
Apple .	30	Browned	*Negundo aceroides*	30	Burnt
Plum	15	,,	*Gleditschia triacanthus*	24	,,
Plum .	10	Attacked	Poplar .	15	,,
Vine	48	Burnt	Raspberry .	34	,,

Gillette found that in a much weaker dose arsenic is still injurious, and that, in this respect, different plants are not equally sensitive

These doses being often insufficient to kill the insects, arsenic solutions were completely abandoned, and replaced by neutral bouillies, in which the arsenic is generally in the insoluble condition, and thus in a form which does not injure the plant. Arsenious acid has also a very decided action on the spores of fungi. This action was long known and utilized to disinfect cereal grains, when, in 1856, Boussingault recommended the use of arsenite of soda for the disinfection of grain. This process was, in his opinion, the best for freeing farm crops from smut, bunt, rust, caries and ergot; it, moreover, had the advantage of protecting the grain from the ravages of injurious animals after sowing.

Arsenic Compounds.—White arsenic is the basis for the manufacture of all arsenical insecticides, some of which, especially the lead and calcium salts, find an extensive use. These are dealt with under

[1] Parts by weight in 100,000 parts by volume.

separate headings Arsenites are prepared by combining arsenious oxide with a base. Arsenates are produced by first oxidizing arsenious oxide to arsenic oxide (arsenic acid) and then combining the material with a base. Except for their water content of approximately 50 per cent, the paste arsenicals have the same general composition as the powdered arsenicals. The usual lead arsenate on the market, acid lead arsenate ($PbHAsO_4$), is well standardized and stable. Basic lead arsenate ($Pb_4PbOH(AsO_4)_3$), also well standardized and stable, is being manufactured at present only to a limited extent Chiefly because of its low arsenic and high lead contents, basic lead arsenate is more stable and therefore less likely to burn foliage than acid lead arsenate. It possesses weaker insecticidal properties and is somewhat more stable in mixtures than acid lead arsenate. Commercial calcium arsenate (arsenate of lime), the manufacture of which is rapidly becoming standardized, contains more lime than is required to produce the tribasic form Paris green, an old and well standardized arsenical, is less stable and contains more " soluble arsenic " than commercial arsenates of lead or lime. The following combinations of insecticides and fungicides were found to be chemically compatible: Lime–sulphur and calcium arsenate, nicotine sulphate and lead arsenate; and Bordeaux mixture with calcium arsenate, acid lead arsenate, zinc arsenite, or Paris green. The following combinations were found to be chemically incompatible: Soap solution with either calcium arsenate or acid lead arsenate; kerosene emulsion with either calcium arsenate or acid lead arsenate, and lime–sulphur with acid lead arsenate. Combined with nicotine sulphate, calcium arsenate always produces free nicotine, and unless a decided excess of free lime is present soluble arsenic is produced. The combination of sodium arsenate with Bordeaux mixture as used in experiments of the U S Bureau of Agriculture gave no soluble arsenic.

Bordeaux-arsenic Dust.—The most common Bordeaux-arsenic dust is blue when moistened with water. A green dust is made from burnt lime, copper sulphate and white arsenic, while a brown dust is made from burnt lime, copper sulphate and arsenic acid. In the control of biting insects all three dusts gave very similar results, being all highly effective against leaf-eating insects such as tent caterpillars (*Malacosoma*), the green dust, perhaps, proving somewhat superior to the others.

Use.—The French Ordinance of 1846, Article 10, " The sale and use of arsenic and its compounds are interdicted for the pickling of grain, the embalming of corpses, and the destruction of insects," has prevented its use in France, but in other countries the valuable properties of this product have earned for it numerous applications. The first trials were made in America in 1867, when Markham used arsenic to combat an insect very deadly to the potato, the *Leptinotarsa decemlineata*[1] or Doryphor of Colorado (the Colorado beetle). The

[1] LEPTINOTARSA DECEMLINEATA (the Colorado beetle)—Deep yellow Coleoptera, closely allied to the chrysomelides; 1 centimetre in length with five black longitudinal lines on each elytrum This insect does great damage to potato fields in America It gnaws the leaves as larva as well as in the perfect state, and produces abortion of the tubers Energetic methods are adopted to prevent it being imported into France [and Great Britain].

use of arsenic became general in 1871, but especially in the form of neutral bouillies, with an emerald green or Scheele's green basis, London purple or arsenite of lime, or in admixture with different anti-cryptogamic salts. Gillette also recommended, in the form of powder, mixed with much flour. In this form it has been recognized as less injurious to the leaves than in solution, and is thus recommended every time that spraying cannot be adopted. To-day white arsenic is hardly used except to poison the pastes for the following insects: *Agriotes lineatus* or *Elater segetis*, L. (wire-worm), injurious to cereals; *Agriotes* or *Elater sputator*, L. (spitting click beetle), injurious to lettuce; *Agriotes* or *Elater obscurus*, L. (dusky click beetle), injurious to carrots. It is very difficult to get at the larvæ, as they live hidden. Comstock recommends to destroy them by pastes poisoned by arsenic. For this purpose small bundles of lucerne are prepared towards July, of which the larvæ are very fond; they are dipped in a 1 per cent solution of arsenious acid, they are then placed in the infected fields, taking care to cover them with flower-pots so as to keep the lucerne moist which should always appear as if fresh cut.

In the Virgin Islands the larvæ of *Pieris* (*Pontia*) *monuste* (southern cabbage butterfly) were successfully controlled by the application of a dust of 1½ parts of a commercial preparation of arsenic (containing 30 per cent of arsenic oxide), 1½ parts of lime and 7 parts of finely ground sulphur.

Grasshoppers.—For making poisoned bran mash for grasshoppers in Minnesota, the formula recommended are 100 lb. coarse wheat bran (free from shorts), 5 lb. crude white arsenic, 5 lb. salt, 3 oz. amyl acetate (technical grade), 2 U.S. gals. molasses (low grade), and 10 or 12 U.S. gals. water.

Gryllotalpa vulgaris (mole-cricket).—To poison this insect Lehmann spreads in the spots frequented by it preparations made thus: thyme, sweet marjoram, sweet basil, with ground arsenic, earth, or sand. The mole-crickets, very fond of these seeds, come to eat them and are poisoned.

Acrydium migratorium (Criquet migrateur); *Acrydium peregrinum* (Criquet pelerin).—Chemicals are only rarely used to combat these locusts; battues and Cypriot's apparatus are preferred. However, Coquillot recommends the use of poisonous preparations. One lb. of sugar is dissolved in enough water to form a syrup, there is then stirred in 1 lb. of arsenic and 6 lb. of bran. This paste is divided into pieces the size of a nut and then laid in front of the line of invasion of the locusts at the distance of a yard and in several parallel rows.

Agrotis segetum, W. V. (the common dart moth); *Agrotis exclamationis* (the heart and dart moth).—Coquillot recommends bunches of lucerne, steeped in a 1 per cent. solution of arsenic, or the preparation already prescribed to destroy locusts. The preparation is placed round the stocks of the vines; the grub, seeking its shelter in the morning on the vine, grazes the arsenic of the preparation and is poisoned by contact, for this product kills the insects that touch it as well as those that absorb it through the digestive channels.

Kermes.—It is asserted that these parasites do not resist a 1 to 3 per cent solution of arsenic.

Phylloxera vastatrix, Planch (phylloxera of the vine).—Arsenious acid was proposed like other substances at the moment of the phylloxeric invasion. The insecticide properties of this product being known, it was hoped to be able to destroy this formidable insect by watering the soil round the stocks with a dilute solution of this poison. The phylloxera infected vines, after having been stripped within a radius of 10 inches round the root, were each treated with 25 grammes of arsenic dissolved in 10 litres of water [Dissolve 2½ lb. arsenic in 100 gallons water and give each vine 2⅕ gallons] The adult phylloxera were found dead, but the young ones were quite robust. As soon as the diffusive action of the soil had rendered the arsenic powerless, the phylloxera multiplied once more. Other trials showed that this dose is quite insufficient to destroy the phylloxera of the vine Vines so infected placed in pots containing 4 litres of earth received 1·5 grammes (23 grains) of arsenic in 100 grammes (3½ oz) of water. This, though a considerable dose, did not free the vine from its parasites. It corresponded to 375 grammes of arsenic per cubic metre of soil, and is not withstood by the vine, which can stand a ¼ per cent. solution, but a ⅓ per cent. affects it. Arsenic has not therefore been judged capable of being taken into account for the destruction of the phylloxera.

Rodents (mice, rats, field mice, moles).—Arsenic is the poison most often used to destroy rats. There are different methods of utilizing it: (1) Boil wheat in water saturated with arsenic; boiling must not be too prolonged, as the grains must remain hard. Place some of the grains, after wiping them, in each hole. To destroy the field mouse it is better to operate in winter, when the animal is famished. (2) Mix 100 grammes of arsenic (3½ oz.) with 1 kilogramme of tallow (say 2¼ lb.), 4 grammes (say ⅛ oz) anise, and 10 grammes (say ⅓ oz.) lampblack. The paste is spread on very thin slices of toasted bread. (3) Mix 4½ oz flour with 1 oz. of arsenic and place a little of the powder in a drain pipe, about 1⅛ inch in diameter; place this pipe near mole holes. This method keeps the poison beyond the reach of game and dogs. These pipes can also be used for poisoned grain. (4) Cut a celery root in two parts, make a cavity in each piece, and fill it with arsenic, then stick the two pieces together by a glue without smell. Thus, after removing the point of one of these roots a conical hole is made in it, arsenic placed in the opening so made, and closed by the piece removed, which forms a natural plug. Place the celery so prepared in the nests. Complete success will be obtained if precaution be taken to accustom the rodents to this preparation by giving them first non-poisoned celery.

Arsenic Acid, As_2O_5.—**Preparation.**—By oxidizing arsenious acid by nitric acid.

Properties.—Arsenic anhydride is a white solid. It dissolves slowly in water. It is a more violent and more rapid poison than arsenious acid

Use.—Arsenic acid has been proposed for the disinfection of seed-corn. A powder is prepared with 9 parts of lime and 1 part of arsenic acid, with which the corn kept moist is sprinkled in the proportion of 3⅓ lb. per 2¾ bushels of grain. After twenty-four hours the seeds were dried and sown.

CHAPTER VI

AMMONIA—AMMONIUM SULPHIDE—AMMONIUM SULPHATE—AMMONIUM CARBONATE—SODIUM HYPOSULPHITE—SODIUM SULPHATE SODIUM CHLORIDE (COMMON SALT)—CAUSTIC SODA—SODIUM NITRATE (CHILI SALTPETRE)—ARSENITE OF SODA—BORAX—SODIUM CARBONATE—SODIUM FLUORSILICATE

Ammonia, NH_3—**Preparation.**—By distilling ammoniacal gas liquor with lime, also synthetically by the Haber and other processes.

Properties.—Ammonia is a colourless gas with a pungent smell, which irritates the mucous membranes, and an acrid taste. Ammonia is one of the nutritive substances of the plant, and its presence in the air greatly stimulates the growth. The dose injurious to plants is about 1000 times greater than the normal dose. Some plants are more sensitive than others Whilst 243 milligrammes of ammonia per cubic metre of air had no bad effect on oaks, even if they remained an hour in that atmosphere, 70—86 milligrammes caused a pathological condition on plum-trees and cherry-trees. A dose of 32–36 milligrammes of ammonia per cubic metre has no caustic action on the most sensitive of vegetables. The symptoms of burning by ammonia are the following: The leaves of the oak blacken; those of cherry-trees and plum-trees become brown; haricots blacken, and cereals lose their colour and become quite pale. Young buds are much more sensitive than old leaves A 0 003 - 0·005 per cent solution has no action on the protoplasma of maize, haricots, tomatoes, and strawberry plants; more concentrated solutions increase the movements of the protoplasma.

The seeds of *Phaseolus multiflora* germinate in nine days in an atmosphere containing 0 003—0·004 per cent. of ammonia; likewise the seeds of *Vicia faba*, when the ambient air contains 0·0031 per cent. of this gas. In an atmosphere containing 0·005 per cent. of ammonia leguminous seeds cannot germinate, and a 0·0083 per cent. solution exercises an unfavourable action on young maize, owing to its diminished growth.

Use.—The causticity of ammonia being known, it is evident that care must be taken not to bring it in contact with plants. Ammonia enters into the composition of certain anticryptogamic bouillies, and chiefly *eau celeste* used to kill mildew. The good effects of this preparation are indisputable, but they can only be obtained by working with an absolutely neutral solution, a point which does not receive in the majority of cases the serious supervision which it requires. It follows that mishaps occur, which should not be produced with a substance possessing all the properties that can be desired. Pure ammonia

has few applications in agriculture. However, gas liquor, which is cheap, is in general use. These ammoniacal liquors kill mosses in meadows and impart fresh vigour to grain crops. But in the condition in which they are bought these liquors are too concentrated, and might kill graminaceous crops. They must be reduced by an equal quantity of ordinary water, and only 4000 litres of this mixture spread per hectare (352 gallons per acre). The following diseases are combated by ammoniacal treatment:—

Heterodera Schachtii, Schmidt (nematode of the beet).—Willot has published very satisfactory results which he has obtained by the use of ammoniacal liquors. The infested beet fields, producing, on an average, 4 tons of beets per hectare, say 1·6 tons per acre, yielded 37 tons per hectare, say 14·4 tons per acre. In Willot's patent the nematodes succumb to the alkaline action of gas liquors, provided they contain 5 per cent. of ammonia. The results obtained by others have not been so favourable Hollrung remarks that beet seed was not capable of springing up in a soil treated with ammoniacal liquor. To avoid this drawback Willot follows up his treatment by spraying with ordinary water. Be that as it may, this treatment cannot be so efficacious as that due to Aimé Girard, which consists in using a strong dose of carbon disulphide, and which ought always to be preferred.

Jassus sexnotatus [1] (grain grasshopper)—Steglich recommends ammoniacal liquor of gasworks, in which 2 per cent of soft soap is dissolved, the whole diluted with an equal bulk of water, to get rid of this pest. Sorauer eulogizes the good effects of this treatment, and recommends spraying with a solution made in the ratio of 30 lb. of soft soap and 3 gallons of commercial ammonia in 100 gallons of water.

Ammonium Sulphide, $(NH_4)_2S$—**Preparation.**—Ammonia forms, when combined with a semi-molecule of sulphuretted hydrogen, hydrosulphide of ammonia or ammonium sulphide.

Properties.—Ammonium sulphide is in the form of yellow crystals which are very soluble in water. It is usually obtained as a yellow liquid which has a very strong smell of rotten eggs.

Use.—*Dematophora necatrix*, Hartig (root rot)—Dufour tried to replace carbon disulphide by this substance, but the results obtained were not perceptible.

Phylloxera vastatrix, Planch (phylloxera of the vine).—Mouillefert found that the phylloxera dies in twenty-four hours in an atmosphere containing 1 per cent. of ammonium sulphide. Used in small dose on a vine in pot where the whole soil could be impregnated with this substance, the result was satisfactory, but on the large scale diffusion is not so perfect, and the result was always incomplete in spite of the toxicity of the two gases which form this salt, ammonia and hydrogen sulphide. Mouillefert experimented thus: The stocks, stripped to 30—35 centimetres (12—14 inches), were watered with 400 cubic centimetres of the liquid sulphide, then with 10 litres of water, after the liquid was absorbed the earth was put back round the stock On roots 50—60 centimetres (20—24 inches) deep the effect was, so to

[1] JASSUS SEXNOTATUS, CICADELLA SEXNOTATA (Cicadella of oats, Cicadella of cereals)—Yellow grasshopper, with brown spots, 3 millimetres long. They suck the leaves of the oats which turn yellow and wither.

speak, *nil*, and it was even observed that the phylloxeras had not been entirely destroyed on the upper roots. According to Couvy and Rohart, this bad result was due to the ammonium sulphide rapidly decomposing in the soil to form inert combinations such as ammonium sulphate

Cochylis Ambignella, Hubn (cochylis of the vine).—Dufour recommends against the grub of this butterfly a solution of 3 per cent. of ammonium sulphide and 3 per cent. of soft soap, which he regards as being more efficacious than carbon disulphide.

An ammonium polysulphide wash is recommended by the British Ministry of Agriculture for destroying American Gooseberry Mildew (*Sphærotheca mors-uvæ*, Berk) The solution is diluted to a strength of 0·11 per cent of polysulphide and used with 0·5 per cent. of soft soap (5 lb of soft soap to 100 gallons of wash)

Ammonium Sulphate $(NH_4)_2SO_4$—Sulphate of ammonia is manufactured commercially by distilling the ammoniacal liquor of gasworks and is also a by-product of blast furnaces and of oil-shale distillation. The volatile portions are collected in dilute sulphuric acid, the liquors obtained are concentrated in lead tanks, where the sulphate of ammonia crystallizes in prisms.

Properties.—Ammonium sulphate forms anhydrous permanent prisms It dissolves in 2 parts of cold and 1 part of boiling water.

Uses.—As an ammoniacal manure.

Heliophobus popularis.—Amongst the insecticides used to destroy the grub of this Lepidoptera, which causes such damage to meadows, Marchand found that only a 10 per cent. solution of ammonium sulphate in purin gave appreciable results.

Phylloxera vastatrix, Planch. (phylloxera of the vine). According to Rosler's experiments on the phylloxera, with the most diverse substances, ammonia had on these plant-lice as energetic an effect as carbon disulphide and sulphuretted hydrogen, but that it had not such a poisonous effect on the plant as the two latter gases. To generate the ammonia gas in the zone invaded by the louse, Rosler recommends piercing holes with the injector round the vine, and filling them either with alternate layers of newly slaked lime and ammonium sulphate, and spray afterwards with water, or with lime alone, and then spray with a solution of sulphate of ammonia. The holes are then plugged with clay or wooden plugs. The ammonia gas generated by the mixture of these substances reaches the phylloxera, and infallibly kills it.

Mouillefert determined that if the phylloxera be sensitive to ammonia it is difficult on the large scale to destroy it with ammoniacal liquor. A phylloxera-infested root dipped for three minutes in ordinary ammonia, or exposed for an hour to the vapours of 5 cubic centimetres of this substance in a 2-litre bottle was freed from all its parasites, but these experiments repeated on a phylloxera-infested vine in pot gave no good results. For that purpose 10 cubic centimetres of ammonia were poured into two holes which were immediately plugged. The beards of the root in existence before the experiment were destroyed and the swellings on the large roots still bore numerous parasites. Ammoniacal liquor, according to this experiment, is not, therefore,

capable of destroying the phylloxera without imparting grave injuries to the plant In fact, 20 cubic centimetres of this liquor employed in the same conditions on a healthy vine burnt the leaves, and 40 centimetres killed them. Ammonia used as vapour does not appear to have the injurious action of ammoniacal liquor on plants. Ammonium sulphate used according to Rosler's indications, may thus have as great an action on the phylloxeras as it has on the vine, by imparting new vigour to it in virtue of its nutritive properties.

Ammonium Carbonate $(NH_4)_2CO_3$—**Preparation.**—By heating in a cast-iron retort an intimate mixture of equal weights of ammonium sulphate and chalk The volatile salt is condensed in a receiver. Another method is by heating ammonium hydroxide with ammonium bicarbonate

Properties.—Ammonium carbonate is a white fibrous mass with a caustic taste and exhaling ammoniacal odour. In contact with air it loses a part of its ammonia and is converted into a more stable bicarbonate Solutions of ammonium carbonate are completely dissociated into ammonia and carbonic acid when heated.

Use.—Hitchcock and Carleton have observed that a 1 per cent. solution of ammonium carbonate stopped the growth of the uredospores of *Puccinia coronata*, Corda, after seventeen hours' action

Phylloxera vastatrix, Planch. (phylloxera of the vine) —The effects of ammoniacal manure, such as ammonium carbonate, which stable manure contains in notable quantities, have always been successful on phylloxera-infested vines Rosler ascribes this to the ready dissociation of this salt into ammonia—especially poisonous to the phylloxera —and carbonic acid So as to render it still more active, he advises the manure containing the ammonium carbonate to be spread in the spring, because the young generations of phylloxera are much more sensitive than the adults Mouillefert is of another opinion. According to his experiments a solution at the rate of 2 lb. of this salt in 25 gallons of water with which he watered a phylloxera-infested vine was incapable of killing the phylloxera. He concluded that ammoniacal salts only acted as fortifiers of the plant.

Sodium Hyposulphite, $Na_2S_2O_3,5H_2O$ —**Preparation.**—Sulphites boiled in presence of sulphur are converted into hyposulphites. To accomplish this, a solution of sulphite of soda is boiled with excess of sulphur until saturated, it is filtered and cooled Large crystals of sodium hyposulphite form. Commercially this salt is prepared by the action of sulphurous acid on calcium sulphide (alkali waste). The hyposulphite of lime formed is converted by sodium sulphate into sulphate of lime and hyposulphite of soda.

Properties.—Hyposulphite of soda is a colourless salt, permanent in air, with a bitter taste and very soluble in water. It is less stable in solution than in crystals; even in the absence of air it is decomposed into sulphite of soda and free sulphur which is deposited. In contact with acids the hyposulphite is decomposed into fine sulphur and sulphurous acid.—

$$Na_2S_2O_3 + 2HCl = 2NaCl + H_2O + SO_2 + S.$$

Heated out of contact with air it splits up into sodium pentasulphide

and sodium sulphate. The use of sodium sulphite has been recommended in medicine, especially against itch. Rubbing with a solution of hyposulphite of soda is followed by washing with dilute hydrochloric acid. The sulphurous acid disengaged and the sulphur precipitated in the pores of the skin make the sulphite a very efficacious agent in the destruction of this *Acarus*.

Action on Plants.—The hyposulphite acts like the sulphite of soda and sulphurous acid. Absorbed by the leaves of plants it is there converted into sulphuric acid and burns the leaves The experiments therefore to replace sulphur by this salt which, so to speak, contains dissolved sulphur have been abortive because it burns the leaves, and the more so the greater the heat. Kaserer observes that it suffices to use a solution of hyposulphite rendered alkaline by milk of lime to obviate this drawback.

Action on Fungi.—Sulphur in hyposulphite of soda preserves its anticryptogamic properties and imparts them to it. Like sulphur hyposulphite of soda has been recognized as capable of killing all fungi, the mycelium of which crawls on the surface of the plant.

Puccinia coronata, Cord. (coronated rust of oats) —Hitchcock and Carleton examined the action of solutions of hyposulphite on the uredospores of this rust and found that a 1 per cent solution has no injurious action thereon, but it exerts a retarding action on the germination and a diminution thereof on the seed steeped therein for twenty-six hours.

Uncinula americana, How. (oidium of the vine) —Pauly examined the action on oidium of a double hyposulphite of soda and silver. After a microscopical examination he observed the great alteration undergone by the mycelium in contact with a solution containing 0·1 to 0·2 per cent. of this salt, and concluded that the use of this salt as a curative agent would give good results However this salt has been abandoned in the treatment of the vine because it burned the leaves especially during great heat, and that much more so than the sublimed sulphur which it was to replace.

By adding 300 grammes of hyposulphite of soda to a 1·5 per cent. bouillie bordelaise, Kaserer obtained by three sprayings in a year complete success in treating oidium without the treatment being followed by the burning of the leaves. Solutions of hyposulphite to which milk of lime was added have been found more energetic than sulphur.

Sphærotheca pannosa (mildew of the rose).—Vesque proposes hyposulphite of soda to destroy mildew of the rose.

Guignardia Bidwelli, Viala et Ravay (black rot of vine).—Pauly remarks that the double salt, hyposulphite of soda and silver, is capable of arresting the progress of the black rot in full evolution; used in a 1 per cent. solution its effect on the spores and the mycelium is most conclusive. This product has therefore been used to destroy this disease by making three sprayings per annum on the attacked vines. This treatment, which burned the leaves, has not been the success anticipated.

Crouzel's anticryptogamic which contains both calcium polysulphide and a little naphthaline, and 0·2 per cent. of hyposulphite of soda is

recommended to combat the cryptogamic diseases of the vine, and particularly the black rot and the oidium. Spraying should alternate with five or six days' interval with those made from copper preparations.

Sodium Sulphate, Na_2SO_4—**Preparation.**—By decomposing sodium chloride by sulphuric acid:—

$$2NaCl + H_2SO_4 = Na_2SO_4 + 2HCl.$$

Properties.—Crystallized sodium sulphate or Glauber's salt contains 10 molecules of water of crystallization. Heated, these crystals melt in their water of crystallization and lose it by igneous fusion. Anhydrous sodium sulphate, a white amorphous powder, is formed. Sodium sulphate reaches its maximum solubility in water at 33° C. It is a neutral body which has no action on plants except when highly concentrated. Seeds, however, do not stand without injury prolonged immersion in a bath of 2 per cent. of sulphate of soda.

Use.—Mathieu de Dombasle discovered the injurious action of this salt on the spores of *smut* and *bunt*, and proposed it to replace common salt then in use to disinfect grain by sodium sulphate. The process in use up to then had many drawbacks. It consisted in macerating the grain in a mixture of lime and common salt for twenty-four hours, and only gave incomplete results. The use of the "Absolute Preservative of Mathieu de Dombasle" was a real progress from all points of view; it shortened the long immersion and gave a better result without injuring the grain treated. *Process.*—Dissolve 8 kilogrammes (17·6 lb.) of sodium sulphate in 100 litres (22 gallons) of water. Spread on the water-tight floor (of a ground floor) 1 hectolitre ($2\frac{3}{4}$ bushels) of the grain to be disinfected and water the heap with this solution, stirring with the shovel until all the grains are well moistened. Then spread 2 kilogrammes (4·4 lb.) of lime recently slaked over the moistened grain, and stir the heap until all the grains are covered with a layer of lime. Hequet d'Herval declares that the success of this treatment is complete, and Loverdo regards this process as that which gives the best result, after Kuhn's blue vitriol disinfection process. Sulphate of soda is, moreover, less injurious to the grain than blue vitriol. Comes has slightly modified this treatment and advises that the spraying of the heap of grain be replaced by immersion in a solution of sulphate of soda. It suffices to immerse the seeds in a concentrated solution of sulphate of soda so that they are completely covered, then add milk of lime and stir for two hours, then spread the grain out to dry. G. Arieti estimates that sulphate of soda has a more injurious action on the spores of *Tilletia* (bunt) than sulphate of potash. He advises not to exceed a 2 per cent. solution for the sake of the vitality of the grain, this quantity being quite sufficient to fulfil the object of sulphating (pickling).

Sodium Chloride (Common Salt), NaCl—**Occurrence.**—Common salt is found crystallized in thick beds in certain countries and is dissolved in water, filtered and crystallized. It also occurs in solution in sea-water and brine springs, from which it is evaporated.

Properties.—Salt is met with as anhydrous crystals. The degree of solubility of the salt in water varies little, whatever be the temperature, 100 grammes of water at 18° C. dissolve 36 grammes of

salt, and at 100° C. 40 grammes. Its use is necessary in the nutrition of the animal; administered in too high a dose, it cannot be eliminated by the skin, the kidneys, and the intestines, and remaining accumulated in the blood it may coagulate the albumen

Rôle of Common Salt.—Sodium chloride or its elements, with few exceptions, are present in almost all plants. A feeble dose of common salt may thus act as a manure for plants, but a strong dose may be so injurious as to kill them. If the quantity of salt used exceeds a certain dose, it stops germination of the seed and the growth of plants. Dieterich proved that big doses of salt completely paralyse the first phases of plant life, and prevent the development of the plant. But all plants and all seeds do not stand the action of salt to the same extent. As a result of some laboratory experiments, it is recognized that barley stands stronger doses of salt than tares, and oleaginous seeds resist salt better than other seeds.

Common Salt as Manure.—To a greater extent than potassium, the sodium necessary to the plant exists in all soils in sufficient quantity. Practice has, however, shown that the application of common salt to a soil rich in sodium is always followed by good results, provided always that a certain dose is not exceeded. In these conditions it is evident that it cannot act as (plant) food, and its rôle must be regarded from another point of view, and possibly the following. According to Braconnot, one of the first effects of salt added to a soil is to keep it moist. This property, which the salt owes to its affinity for water, is in a high degree favourable to the transport of the elements assimilated in the plant. Liebig and others agree in attributing to common salt the rôle of a solvent of phosphate of lime. Liebig found that a solution of 1 kilogramme (2 2 lb.) of common salt in 500 litres (110 gallons) of water dissolves 15 grammes, say ½ oz., of phosphate of lime. The good effects of salt may be confirmed by spreading a small quantity on the land. In big doses it is, on the contrary, antiseptic and prevents the putrefaction of organic matter in the soil, and consequently the formation of nitrates. The nitrification of organic matter goes on slowly in cold weather; salt, therefore, has more action in southern countries than in northern countries. For the action of salt on arable land to be complete heat and moisture must be intermittent. In dry years salt may be injurious, because it then acts as a caustic, and corrodes the plant. Plants on the sea-coast are watered naturally by the salt water of the sea. Where the desiccating action of the wind cannot wither up plants sheltered behind walls, hedges, or forests, vegetation becomes luxuriant. It is otherwise quite on the seashore, the excess of salt, especially magnesium chloride, being as injurious to plants as the drying wind. Barren zones are thus to be found along the shore. The experiments of Lecocq have shown that it requires 150—200 kilogrammes (330—440 lb.) of common salt per hectare, say 132—176 lb. per acre, as a manure for lucerne, 250- 300 kilogrammes (550—660 lb., say 220—264 lb per acre) for flax and wheat, and 264 lb. per acre for barley. Others have confirmed these figures and give 264—440 lb. per acre as a suitable dose.

Use against Injurious Plants.—Salt in excess is injurious, and certain plants stand it with difficulty. Wendler found common salt

an excellent means of destroying charlock. Waste salt may be used with good effect as a weed-killer on garden paths. A strong dose of salt has a corrosive action on delicate plants, thus mosses and horse-tails which invade meadows succumb long before the gramineæ. Used on meadows and fields in a dose to kill moss, it only retards the growth of the gramineæ, applied on corn fields, it keeps the stem shorter, imparts a certain rigidity and prevents laying Watering paths with a 10 per cent. solution is the method used to destroy weeds, unfortunately it only destroys them momentarily and imperfectly because they spring up again as soon as rain comes to wipe out the treatment. It is more effective when applied in a dry state. Top-dressings of salt at the rate of 5 to 7 cwt per acre have, in some cases, proved very effective against the weed Yellow Rattle (*Rhinanthus Crista-Galli*, L). There is a risk, however, of this treatment seriously damaging grass or clover.

Use of Common Salt against the Diseases of Plants.—*Bacterian diseases of the potato, scab, crevices*, etc —Becquerel experimented with common salt on the diseases of the potato. This product, in big doses, being an antiseptic, it might, therefore, prevent the extension of these diseases. The potatoes were planted in winter, and to prevent the frost getting at them the tubers were planted at a depth of 15 inches, with 10 grammes of salt, and others without any saline manure. In the salted ground the potatoes could be harvested two months before the normal time, and whilst on the ordinary soil there were 10 per cent. of diseased potatoes, on the soils supplied with salt all the tubers were sound. According to Peters there is even an increased yield, but on the other hand a diminution in the total amount of starch. The same result occurs, therefore, as with the beet, the improvement brought to bear on this crop by common salt and the increased yield are rather illusory, since the weight of the beet increases whilst that of the sugar diminishes

Rust of Cereals.—Solutions of common salt were tried to combat this disease on the adult plants. Feburier and Phillipar obtained good results by spreading either salt or a mixture of salt and lime on the crop, but this improvement has been disputed by Loverdo.

Use in the Destruction of Insects.—Salt is not an insecticide, but its presence in the soil sometimes renders a sojourn there impossible or disagreeable to certain insects.

Agriotes lineatus, L. (wire-worm) —The larvæ of this insect have been combated by spreading a strong dose of salt on the fields. Comstock and Slingerland found that by mixing 10 tons of salt per hectare (4 tons per acre) with 10 centimetres (4 inches) of the arable surface soil these larvæ died; with only 7½ tons per hectare (3 tons per acre), the effects were imperceptible. Unfortunately to obtain good results such large doses of common salt must be used that growth cannot take place normally; hence it has been advised to apply salt during the bare fallow, as the latter is incapable by itself of diminishing the number of polyphagous larvæ.

Pieris (white cabbage butterfly).—The grubs of the *Pierides*, which ravage cabbages, may be destroyed by watering the latter with a solution containing 250 grammes of salt and 250 grammes of tobacco

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juice in 14 litres of water, say 1 lb. of salt and 1 lb. of tobacco juice in 5—6 gallons of water.

Salt has been used to kill plant lice but is useless against Phylloxera.

Schizoneura lanigera, Hausm. (woolly aphis)—Krafft recommends the following emulsion, which yields a satisfactory result: Petrol 800 cubic centimetres, salt water, 25 per cent., 200 cubic centimetres.

Aspidiotus perniciosus, Comst. (the San José louse).—In California a mixture of lime, sulphur, and salt is employed against this insect, but this preparation has been abandoned in the Eastern States owing to certain failures, and better results got by the use of whale-oil soap-emulsions.

Caustic Soda, ($NaOH$)—For a winter wash for fruit trees the British Ministry of Agriculture recommends 2 lb. of powdered caustic soda in 10 gallons of water. The soda, of 98 per cent. purity, is dissolved first in a little water and then diluted to the proper strength. The face and hands should be protected during use. Another winter wash (1 per cent. solution) which, according to the British Ministry of Agriculture, has proved useful in preventing severe attacks of wither-tip and brown rot (*Monilia cinerea*) in plums and cherries is made from: caustic soda, 1 lb., soft soap, 1 lb., water, 10 gallons.

Nitrate of Soda, $NaNO_3$—**Occurrence.**—Nitrate of soda or Chili saltpetre forms thick beds, which extend on the surface of the soil under a thin bed of clay.

Properties.—The crystals of nitrate of soda are anhydrous, permanent in dry air, but deliquescent in moist air. They are much more soluble in hot water than in cold water, 100 grammes of water dissolve 80 grammes of nitrate at 10° C. and 217 grammes at 119° C.

Action on Plants.—Nitrate of soda is a plant food, but like most salts in strong solution, it is injurious to certain plants. Steglich submitted the most diverse plants to a 30 per cent. solution and to one of 15 per cent. with the following results:—

TABLE XVII.—*Showing the Effect of a 30 per cent. Solution A and of a 15 per cent. Solution B of Nitrate of Soda on Different Plants.*

Plants.	A.	B	Plants	A	B
Grain	Fleeting 5–7 days	Nil	Charlock .	Very sensitive	Very sensitive
Beets .	Nil	,,	Sorrel .	Nil	Nil
Potatoes	Deadly	Deadly	Knot grass	,,	,,
Trefoil	Slight	Nil	Horsetail	,,	,,
Lupin	Deadly	Deadly	Peas. .	,,	,,
Flax .	,,	,,	Mustard	Deadly	Deadly

The property of nitrate of soda of killing certain plants without killing others has been utilized in farming to free fields invaded by certain adventitious plants. Duserre recommends the use of a 20 per cent. solution to destroy mustard in cornfields. It is preferable not to use nitrate of soda alone, but mixed with a little blue vitriol. The young mustard dies after watering with a solution containing 10 per cent. of nitrate of soda and 2 per cent. of blue vitriol. Older mustard requires

a solution containing 3 per cent. of blue vitriol and up to 20 per cent. of nitrate of soda, 10 hectolitres (22 gallons) of this solution are required per hectare ($2\frac{1}{2}$ acres). The use of nitrate of soda has, in this case, the advantage of serving as a manure to the grain crops, and by stimulating their growth renders them more apt to struggle against parasites. However, Nijpels believes that nitrate of soda, as the sole manure, encourages the development of the rust of cereals

Action on Fungi.—Nitrate of soda should, logically, act like nitrate of potash on the spores of fungi. The latter salt has been studied in a very complete manner by Wuthrich.

Action on Insects.—Smith regards a 4 per cent solution of nitrate of soda as a good insecticide. Concentrated solutions of nitrate of soda spread on the land are injurious, according to Miss Ormerod, to the larvæ of the *Tipula*, according to Taschenberg, to the larvæ of the *Elaterides*, and according to Weiss, to *Nematodes*, and particularly to the *Tylenchus devastatrix*, Kuhn (eelworms of wheat), which cause the disease known as the *Niel du Froment*.

Arsenite of Soda, Na_2HAsO_3—**Preparation.**—By boiling 1 part of arsenious acid with 2 parts of soda ash.

Properties.—Arsenite of soda is much more soluble in water than white arsenic and consequently much more poisonous to plants. In the composition of arsenical bouillies its formation must be guarded against, or its effects neutralized by the addition of lime.

Use.—The soluble arsenites, such as the salts of potassium, ammonium, as well as the soda salt, have been serviceable owing to their great solubility and their immediate action on insects and injurious animals But this use is, perforce, limited, and it can only be used to poison preparations to be eaten by insects and rodents.

Note by Translator, re *Arsenite of Soda*—This substance is made a speciality of by at least one firm in Great Britain who sell it in a more or less concentrated state of solution. Several accidents have occurred from the solution having been drunk inadvertently, and some deaths occurred through leakage of a cask on to sugar casks during transit. To prevent such occurrence and render them more difficult the protective coloration of arsenical weed-killers is recommended While the revision of this work was in progress the Railway Clearing House was informed that the Council of the Pharmaceutical Society had directed further investigations to be made with regard to the possibilities of potassium bichromate as a colouring agent for liquid weed-killers. The Railway Clearing House wrote forwarding a copy of a communication which had been sent to manufacturers of liquid arsenical weed-killers, etc. This stated that, as the result of further experiments which had been made by the railway companies' chemists with respect to the colouring of liquid arsenical weed-killers, it had been found that of the dyes tested the one most generally satisfactory was disulphine blue V, obtainable from the British Dyestuffs Corporation, Ltd. The matter had been independently the subject of investigation by the Pharmaceutical Society, and it would appear that of the dyes tried by them the same dye proved to be the best. The proportion in which the dye was added was 1 oz. to 10 gallons The railway companies thought the manufacturers would be interested to know

this, and added: "If you find any blue dye which shows improvement in permanence and quality over disulphine blue V, the companies would esteem it a favour if you would be good enough to call their attention to it."

A mixture of molasses and sodium arsenite for poisoning the olive fly (*Dacus oleæ*), recommended by Prof. A. Berlese, has a content of over 90 per cent. of molasses of consistency 1·41, in the proportion of 40—45 of sugar to 2·5 of sodium arsenite. The mixture only requires dilution with 9 parts of water, and about 10 oz. of spray is required per tree for one application Against grasshoppers in Wisconsin the following arsenical bait had advantages. 100 lb sawdust, 1 U S qt sodium arsenite, 5 lb salt, 1 U S. gal black strap molasses, and 10 U S gals water, the quantity per acre being 10 lb

Preparations to Kill Locusts.—In the British Colonies they prevent the migration of locusts by placing in their way bunches of fodder, herbs, or maize stems, steeped in a solution containing per hectolitre 60 grammes of arsenious acid, 60 grammes of caustic soda, and 10 kilogrammes of white sugar or molasses [or 60 oz (wt.) of arsenious acid, 60 oz. of caustic soda by weight, and 1000 oz of sugar (wt.) in 100,000 fluid ounces of water] Drying is prevented by covering the bait with a board or a stone. This bait may be used for other insects

A leaflet issued by the Rhodesian Department of Agriculture concerning the destruction of locusts by means of sodium arsenite sprays, recommends, for young hoppers (within two weeks of hatching), 3½ oz. (by weight) of dry sodium arsenite or 3 fluid oz. of concentrated solution to 4 gallons. For older hoppers the strength may be slightly increased but should never exceed 4½ oz. by weight or 4 fluid oz to 4 gallons The dry sodium arsenite should be dissolved by heating in a little water over a fire, and then the rest of the water should be added. For extensive operations 11 lb of the dry sodium arsenite can be boiled in 1 gallon of water and 3 fluid oz. of this solution used in 4 gallons of water for spraying When dry sodium arsenite is used, care should be taken that it has entirely dissolved in the vessel before use. In Russia poisoned baits (40 lb. of bran or sawdust, 2½–5 lb. of sodium arsenate, 4 gallons of water) have been tried, with excellent results.

Russian experiments for the control of locusts showed that finely-powdered sodium arsenate applied to rye at the rate of one part by weight to 20 parts of chalk does not injure the plants. The locusts would only feed on the treated plants during the first twenty-four hours, after which symptoms of poisoning were evident. By the fifth day, 96 per cent were dead, and none survived longer than the sixth day. In a popular bulletin on grasshoppers, the recommendations for control are poisoned baits consisting of 40 lb sawdust or dry horse dung, 1½ lb. sodium arsenate or Paris green, and 3 gals. hot water.

Arsenite of Soda as a Weed-killer.—A first-class weed-killer could be made by dissolving arsenite of soda so that the diluted liquid would contain 1 oz. arsenite of soda per gallon: down to half that amount, however, could be used. These limits are represented by 8 lb. of arsenite of soda 80 per cent. down to 4 lb. in the concentrate.

Borate of Soda, $Na_2B_4O_7$.—Borax occurs naturally in the lakes of

Asia and Italy, from which it is extracted by evaporation and crystallization.

Preparation.—By gradually adding 100 lb. of Tuscan boric acid to 125 lb. of soda crystals dissolved in 20 gallons of water and then heating by steam. The mixture is concentrated to 30° Bé., and cooled slowly; crystals of borax form at the bottom of the receiver. The double borate of soda and lime, or boronatrocalcite, is widely distributed in America; it is now used to manufacture a large amount of borax, obtained by boiling this product with carbonate of soda.

Properties.—Borax is freely soluble in water. One hundred lb. of borax dissolve in 120 gallons of cold water and the same amount in 20 gallons of boiling water. Its solutions react alkaline. Borax is used in medicine as an antiseptic, especially in throat and mucous affections. It is used to preserve meat and putrescible liquors. Wernicke found it more active from that point of view than boric acid. Its antiseptic and bactericidal capacity is, however, very weak. Kuhn found that it only acted in 2 per cent. solution. Schwartz, however, found that the bacteria of the infusion of tobacco were exceptional, and that a 0·5 per cent. solution had already a certain effect on these microbes. Wenckiewicz found that it had no action on *Penicillium glaucum* until its solution reached 1 4 per cent. Borax exerts a poisonous action on plants. By watering haricots with a very dilute solution of borax Peligot first induced chlorosis, then death.

Use.—Borax has been recommended in 5 per cent. solution in America against the *Peronospora viticola,* de By (mildew of the vine). At that strength it can check the disease, but its use is not without drawback, for it burns the leaves of the vines treated. Care should be taken to wash these a few hours after treatment. Muhlberg found borax solutions did not kill the *Schizoneura lanigera,* Hausm., against which it had been recommended. If the manure is not wanted for field or garden work, borax may be used for destroying the larvæ of house-flies in manure-heaps. Applied in the proportion of 62 lb. per 10 gallons of water for every 8 bushels of manure, borax solution will be quite as effective as the hellebore solution, and will be much cheaper. A daily sprinkling of the refuse heaps and of stable, cowshed, or out-house floors with one of the solutions is recommended.

Carbonate of Soda, Na_2CO_3 —**Preparation.**—By the Solvay process principally. A concentrated solution of common salt is first saturated with ammonia, then a prolonged current of carbonic acid is passed through; bicarbonate of ammonia is produced, which acts on the common salt to convert it into carbonate of soda. The precipitate is filtered, drained, and calcined. The Leblanc process is almost superseded, but the ammonia-soda process is making way.

Properties.—Carbonate of soda crystallizes in prisms, the crystals lose their water of crystallization at the ordinary temperature. Heated, they melt in their water of crystallization, dry, and form calcined carbonate of soda (soda ash) which is an amorphous white powder containing no water. Soda crystals are much more soluble in hot water than in cold: the maximum solubility is at 38° C.; 1 gallon of water dissolves 6·04 lb at 14° C., 166 6 lb. at 38° C., and 44 5 lb. at 104° C. Carbonate of soda in solution has a strong alkaline reaction.

Action of Carbonate of Soda on Plants.—Around alkali works the presence of this salt, carried by the wind, does much damage. Eventually the carbonate of soda, covering the leaves with a white layer, more or less thick, causes them to drop off, and kills the trees themselves. Rye suffers much from contact therewith, the ears are almost empty, and the few grains which they contain are shrivelled and blackish. When plants have been in contact with carbonate of soda the analysis of the ash reveals a quantity of soda superior to the normal quantity. The straw of cereals is more brittle, and contains less silica. Carbonate of soda acts like carbonate of potash; when it is a case of neutralizing the acidity of certain marshy lands carbonate of soda may play the part of lime, and the nitric ferments, which cannot act except in slight alkaline media, may thereby modify the flora of the field. In such conditions carbonate of soda, in small doses, may exert a favourable influence on vegetation.

Action on Fungi.—Wuthrich treated the spores of different fungi with sodium carbonate with the following results: A solution of 0·053 per cent. prevents the conidia of the *Phytophthora infestans*, de By, from producing zoospores, but it does not injure their direct germination; life is only arrested by immersing the conidia in a 0 53 per cent. solution. As to the conidia of the *Peronospora viticola*, de By, Wuthrich found sodium carbonate more energetic, a 0·053 per cent. solution hindered the growth of the spores, and a solution of 0 53 per cent. stopped it entirely. The uredospores of *Puccinia graminis*, Pers., show, more than any other spores, a great resistance to carbonate of soda solutions, but germination is hindered by 0·53 per cent solution and stopped entirely by immersion in a 2·65 per cent solution.

Action on Insects.—All soft-skinned insects are sensitive to strongly alkaline substances, but these substances in themselves are not very powerful insecticides, they are, therefore, combined with toxic substances.

Use.—Carbonate of soda enters into the composition of certain copper bouillies, but it has no other function than to decompose the blue vitriol into carbonate of copper and sulphate of soda. An excess of carbonate of soda must be avoided in the preparation of Burgundy or cuprosodic bouillies, because these evaporating on the leaves may give rise to the same bad effects as carbonate of soda and cause the leaves to drop —*Black Spot on Roses.*—U S. Lodge states that sodium carbonate meets the five requirements which are necessary in the spray to control Black Spot: "Killing effect on the spores of the various fungi, non-poisonous character, cheapness, ease of making up, and lack of any tendency to damage either flower or foliage. The common form is a crystalline salt containing a large percentage of water crystallization; in the dry form this excess water is removed. Upon standing for a time, the crystalline salt has a tendency to convert a portion of itself into bicarbonate of soda. The proper strength of the solution used is important. Too strong a solution will crystallize upon the foliage and eventually destroy a portion of it, too weak will not have the desired effect. If the crystalline salt is used, the proper proportion is approximately 1½ oz. to the gallon of water. If the dry salt is used, then ¾ oz. to the gallon of water should be used. The

chemical should be dissolved in a small quantity of very hot water, and then the balance of the water added. It will be found advisable to add whale-oil soap, for this solution will not 'stick' to foliage or stems. Sufficient force should be used in spraying to force the solution through the bushes, so that leaves and stems are well covered on top and underneath. The plants should be sprayed twice a week with clear water to wash off the foliage, and the washing should be followed within six hours by the above spray. Three days is about as long as the sodium carbonate will remain active enough to perform its purpose. In that time a certain proportion of the chemical is taken up by the leaves in the form of carbonic acid gas and used as food."

Sodium Cyanide.—The British Ministry of Agriculture recommends that an article sold as sodium cyanide for agricultural and horticultural purposes should be capable of evolving (when treated with an acid) not less than 54 per cent of its weight of hydrocyanic acid.

The procedure to be followed in the fumigation of foreign cotton as a preventive against *Pectinophora gossypiella* is given in an order of the U.S. Federal Horticultural Board. The rate is 6 oz. of sodium cyanide per 100 cubic feet. The cotton to be fumigated is placed in the fumigating chambers, the doors to these chambers are closed, and the air is exhausted until the vacuum gauge registers 25 inches. At this stage the gas is generated in a retort connected with the large chamber. The valve of the connecting pipe is opened; after the expiration of 15 minutes air is allowed to pass through the generator for 5 minutes for the purpose of removing any gas which may be present. The air valve on the fumigating chamber is then opened and the air allowed to rush in until the gauge registers 5 inches. The cotton then remains in the chamber for 1 hour and 40 minutes, making the total process of fumigation 2 hours After the completion of the exposure, to remove the gas the pumps are run again and a vacuum of 25 inches is established. At this stage the valves are opened and the pumps kept running for some time to complete the washing out of the gas from the bales. The pumps are then stopped and the doors of the chamber opened so that the cotton can be removed and another lot put in. The results of tests indicate that such fumigation of cotton did not cause any deterioration of the cotton, either as to percentage of waste, spinning qualities, tensile strength, or bleaching, dyeing, or mercerizing properties of the cotton.

The action of sulphuric acid on sodium cyanide is identical with its action on the potassium salt (see below, Chap VII), and is as follows .—

$$2NaCN + H_2SO_4 = Na_2SO_4 + 2HCN.$$

According to this reaction, 1 oz (avoirdupois) of sodium cyanide requires 1 oz. (avoirdupois) of sulphuric acid, H_2SO_4, or 1·07 oz. of commercial sulphuric acid containing 93 per cent. of sulphuric acid, which is equivalent to 0 56 fluid oz. To get the best yield of gas the sulphuric acid must be in considerable excess, when the reaction would be :—

$$NaCN + H_2SO_4 = NaHSO_4 + HCN,$$

or for each ounce of sodium cyanide there would be required 2·14 oz (avoirdupois) of 93 per cent sulphuric acid, equivalent to 1·12 fluid oz.

Sodium Fluorsilicate.—Sodium fluoride has been proved efficient in the U S A. for killing roaches and chicken lice, but cannot be used on plants because of its scorching effect, due to solubility As a result, the use of sodium fluorsilicate has been tried with successful results in connection with plants Field trials were made with a dusting powder of hydrated lime nine parts and the fluorsilicate one part by volume, and was found effective for the destruction of the Mexican bean beetle, the Colorado potato beetle, the potato flea beetle, the bean leaf beetle, and the tobacco hornworm. Under laboratory conditions, its use was also efficient for the cotton boll weevil. At the Department of Insecticides and Fungicides Rothamsted Experimental Station, Harpenden, shoots of hazel were sprayed with very fine suspensions of sodium and potassium silicofluorides in water, allowed to dry, and transferred to lamp glasses fitted with a cork at the lower end through which the stalk dipped into water, the open top of the vessel being covered with muslin. Ten larvæ of *Selenia tetralunaria*, Hufn , were then placed on each twig and observed from day to day. The state of affairs after four days was as follows .—

	Per cent	Unaffected	Slightly affected	Moribund.	Dead
Sodium silicofluoride	1	—	—	1	9
	0 75	—	2	4	4
	0 5	7	—	1	2
	0 25	9	—	—	1
Potassium silicofluoride	1	1	—	—	9
	0·75	1	—	—	9
	0 5	5	—	3	2
	0 25	10	—	—	—

The toxicity was slightly (probably not significantly) less when 1 per cent. of saponin was added to the spray fluid. The foliage was uninjured by the treatment.

CHAPTER VII

POTASSIUM HYDROXIDE (CAUSTIC POTASH)—POTASSIUM SULPHIDES (LIVER OF SULPHUR)—POTASSIUM CHLORIDE (MURIATE OF POTASH)—POTASSIUM NITRATE—POTASSIUM SULPHOCARBONATE—POTASSIUM XANTHOGENATE—POTASSIUM CYANIDE (PRUSSIC ACID)—POTASSIUM SULPHOCYANIDE.

Caustic Potash, KHO—**Preparation.**—By decomposing carbonate of potash in solution in water by lime a precipitate of carbonate of lime is formed, and potassium hydroxide enters into solution :—

$$\underset{\text{Potassium carbonate}}{K_2CO_3} + \underset{\text{Calcium hydroxide}}{Ca(OH)_2} = \underset{\text{Potassium hydroxide}}{2KOH} + \underset{\text{Calcium carbonate}}{CaCO_3}$$

Properties.—Caustic potash is a white deliquescent solid, exposed to moist air it absorbs water and carbonic acid. Potash, even in dilute solution, is a strong caustic which softens and gradually dissolves the skin, it traverses and perforates the mucous membranes, it is a strong poison, which should be handled carefully. It is used in surgery as a cautery. [Antidote, vinegar]

Use.—Potash solutions have been used in America against different plant lice, which, owing to the chitinous protections covering them, greatly resist insecticides The caustic nature of potash gives access to the insect by removing these obstacles. (See above *re* Caustic Soda)

Potassium Sulphides, K_2S to K_2S_5—**Preparation.**—Potassium monosulphide is prepared by heating carbon and potassium sulphate; or from caustic potash, by saturating a 30 per cent. solution with hydrogen sulphide, when potassium hydrogen sulphide and water are formed :—

$$KOH + H_2S = KHS + H_2O.$$

The same amount of 30 per cent. caustic potash is afterwards added, which reduces the hydrosulphide to the monosulphide :—

$$KHS + KOH = K_2S + H_2O.$$

To obtain the polysulphides it suffices to heat the monosulphide with 1, 2, 3, or 4 atoms of sulphur.

Liver of Sulphur is a mixture of polysulphides, but it contains especially the pentasulphide of potassium. It is preferably obtained by heating to redness in a crucible equal parts of sulphur and carbonate of potash. By the action of heat the carbonic acid is disengaged and the sulphur combines with the potassium. When the disengagement of carbonic acid is finished, the liquid is run on to an iron plate where it

solidifies immediately; it is then broken up and preserved out of contact with air. It forms a reddish-brown solid which smells of rotten eggs.

Formulæ of the British Ministry of Agriculture.—

(*a*) Potassium Sulphide (Liver of Sulphur) Wash. (Original formula.)

Potassium sulphide	5 oz.
Soft soap	½ lb
Water	10 gall.

In preparation the soap and potassium sulphide are dissolved in the water.

(*b*) Potassium Sulphide (Liver of Sulphur) Wash. (Lloyd's formula.)

Potassium sulphide	1 oz.
Flour	1½ oz.
Water	2 gall.

"Place 14 pints of water in a bucket and add 1 oz of liver of sulphur which will completely dissolve while the flour paste is being prepared. Make 1½ oz. of ordinary wheat flour into a smooth paste with a very little water. Add water to 2 pints till the mixture is as thin as milk and as free from lumps. Boil this until it froths up, stirring it all the time. Add it to the solution of liver of sulphur and mix thoroughly. Apply with a hand or knapsack sprayer and wet the plants all over. The flour paste must be used the day it is prepared, and any mixed spray remaining at night must be thrown away." This wash is recommended for use against "red spider" on fruit trees.

Properties.—The sulphides are very deliquescent and soluble in water in all proportions. They must be kept out of contact with air; carbonic acid in presence of moisture rapidly decomposes them into potassium carbonate and hydrogen sulphide. Solutions of the monosulphide are colourless, those of polysulphides, on the other hand, are yellow. Sulphides retain the alkaline properties of caustic potash, attenuated by sulphur. In medicine, sulphides are used to treat skin diseases due to acarium. Plants do not stand spraying with sulphide solutions, these being generally used very dilute. The sulphuretted hydrogen given off by decomposition is poisonous to the plant in a 0·75 per cent. dose, but it is only formed gradually, so that the amount in contact with the plant is not sufficient to cause any ill effect. Leaf burning is less frequent than with sublimed sulphur.

Use.—Sulphides are used to combat. (1) *Cryptogamic diseases*, either by spraying the plants or by immersion to disinfect the seed against anthracogenic parasites. (2) *To kill insects.* To impart more adherence and a longer action, a soap and glycerine emulsion is used. Polysulphides of potassium are used in the same proportion as sulphur, for they decompose under the action of carbonic acid and air and organic acids into potash salts, hydrogen sulphide, and sulphur:—

$$K_2S_5 + CO_2 + H_2O = K_2CO_3 + H_2S + 4S.$$

The sulphur is precipitated in a fine state of division, and thus its anticryptogamic properties are at a maximum. It can thus be said that the action of polysulphides is appreciably identical with that of sulphur, and especially of precipitated, impalpable sulphur if used in the same temperature conditions. In studying their application it will be seen that they have entered into current practice as substitutes for sulphur in killing numerous *Erysipheæ* and to stop the development and extension of certain fungi by the destruction of their *conidiophores*. In sulphides the caustic action aids that of sulphur. Not only do sulphides have a decided action on fungi and their spores, but the potassium carbonate formed by their decomposition has a decided action on fungi, whose growth it prevents The growth of conidia of *Phytophthora* and of *Peronospora* is stopped by a 0·7 per cent. solution, their zoospores being no longer able to develop. The spores of *Ustilago Carbo* and of *Claviceps purpurea* as well as the uredospores of *Puccinea* are more resistant than the former, for a 0·7 per cent. solution hardly hinders their growth, whilst a 3 5—7·5 per cent. solution stops it.

As insecticides, sulphides act in virtue of their caustic properties, and the sulphuretted hydrogen given off by their decomposition, this gas being for insects almost as poisonous as prussic acid. It is, moreover, asserted in medicine that sulphides used in 5—20 per cent. solution in skin diseases, such as itch, act on the parasites by the sulphuretted hydrogen formed in contact with the organic acids of the transpiration and the carbonic acid of the air.

Use against Bacteria.—Sulphides retard putrefaction and kill microbes (Amsler). It has been tried to utilize this property to treat plant diseases of bacterian origin, such as potato scab. The bacteria which causes this disease of the potato is found, according to Bolley, in the living tissues of the periphery of the tubers and never penetrates deeply; it is aerobic. Bolley has submitted tubers so attacked for twelve hours to the action of a 0 3—0·4 per cent solution of potassium sulphide before planting them. At that strength the causticity of the sulphide is not sufficient to injure the tubers. An appreciable effect was obtained, but the sulphide has not the radical effect of mercury bichloride. The results obtained by the sulphide are still defective—5 per cent of healthy tubers against 1 per cent in a blank field.

Gum Disease of the Olive (Mal di Gomma of the Italians) —Swingle and Weber advise to combat this disease by potassium sulphide · 18 kilogrammes (39·6 lb.) of potassium sulphide are dissolved in 15 litres (3·3 gallons) of water; to this paste 12 kilogrammes (26·4 lb) of 98 per cent. caustic soda are added and energetically stirred. The mass heats, boils, and melts. As soon as boiling is over the bulk is made up to 100 litres (22 gallons) with water. The cankers and wounds formed by the disease are cleaned, diluted before use with an equal bulk of water; the roots, even sound ones, are stripped and watered with a solution of this sulphide in 10 parts of water.

Use against Fungi.—Pickling of Seed-Corn.—Dilute solutions of potassium sulphide prevent the growth of fungi and their spores and may kill them if of a certain strength. The action of the sulphide is not the same on all spores, *e g.* it is almost *nil* on the spores of *Phytophthora phaseoli*, Taxter (Lima bean mildew). Hitchcock and Carleton

remarked that a 1 per cent solution not only did not destroy the uredospores of *Puccinia graminis*, Pers (black rust) and *Puccinia coronata*, Corda (coronated rust of oats), but rather accelerated their germination. By numerous experiments on rusts Galloway came to the same conclusion. The disinfection of grain in 0·75 per cent. solution made no diminution in the rust By spraying winter wheat no appreciable result was obtained unless spraying with a 0·5 per cent solution was repeated every ten days. Under such conditions he obtained 1 diseased plant against 24 in the blank plot. If twenty days' interval occurred between the sprayings the rust did not diminish but the harvest was a little better. Kellermann and Swingle were the first to observe the sensitiveness of the spores of smut to sulphide, especially the loose smut of oats. Jensen tried if grain could not be disinfected by sulphide against smut. The results which he obtained were surprising, and he did not hesitate to advise it in place of steeping in hot water recommended by him some years previously. Numerous experiments show, however, that the sulphide is not capable of rendering better services than the Jensen hot-water treatment or that of Kuhn with blue vitriol or that by mercuric chloride. It generally gives very irregular and sometimes imperfect results, for example, against *Smut of Wheat* (Rostrup). It has, however, a serious application in the disinfection of oats, where it is superior to any other treatment in destroying the spores of *Ustilago avenæ*, Rost. (loose smut of oats). This treatment is practised in Denmark where it is highly esteemed. Steeping should last twenty-four hours in a 0 75 per cent. solution.

Helminthosporium gramineum, Eriks. (black mould of cereals).—Kolpin Kavn found steeping grain in the sulphide is a good precaution against this disease.

Spraying with Dilute Solutions.—The *Erysipheæ*, the mycelium of which is not protected by the tissue of the plant attacked, may be combated by potassium polysulphides. Owing to their decomposition the sulphur is deposited between the filaments spread on the surface of the organs attacked, and acts in a more certain manner than sulphur used against the same disease. In spite of their properties the sulphides of potassium are not used to combat the oidium. Gardeners use them against *Microsphæra grossulariæ*, Wallr. (gooseberry leaf-mildew); *Sphærotheca mors uvæ*, B. et C. (American gooseberry mildew), which they cure radically. Close prefers a 0·3 per cent. solution of potassium sulphide to the fungicides, usually employed by sol, formol, and bouillie bordelaise. Goff advises spraying with a 0·2—0·4 per cent. solution as soon as the leaves appear, and to renew it after each heavy rain until the plants are completely in leaf, and from time to time in summer. He obtained the following results : The fruit garden check plots showed 11·3 per cent. diseased plants, after 0·2 per cent. treatment 7 per cent., and after 0·4 per cent. 1·7 per cent. of diseased plants.

Sphærotheca pannosa, Lev. (rose and peach mildew).—This fungus may be combated efficaciously by potassium sulphide. Vesque recommends spraying with 1 per cent. solutions, Mohr 2 per cent. liver of sulphur, to which he adds 2 per cent. of glycerine to render it more active and adherent. A concentrated bouillie is prepared by dissolving 200 grammes of liver of sulphur and 200 grammes of glycerine in a litre

of water (say 2 lb. of each in a gallon of water) and the solution kept out of contact with air until required for use, when it is diluted with ten times its bulk of water.

Sphærotheca Castagnei (hop mildew).—Salmon recommends 0·1 per cent solutions, Selby 0·2 per cent. solutions.

Amongst the fungi living in the interior of plants which cannot be reached, a certain number may be combated by destroying the conidiospores which contribute to their rapid propagation. These are :—

Alternaria brassicæ f nigrescens,[1] Peglion (scorching of the leaves of the melon).—Sturgis used potassium sulphide with much success.

Sphærella fragariæ, Sacc (spotting of the leaves of the strawberry).—Potassium sulphide has been used successfully in America by Buffum and Arthur against this parasite of the strawberry to prevent its too great extension.

Guignardia Bidwelli, Viala et Ravaz (black rot).—Galloway obtained satisfactory results with 0·1 per cent solutions of liver of sulphur: blank vines 65·64 per cent of sound grapes; vines sprayed six times, 75·17 per cent. of sound grapes. This treatment cannot compete with that of copper salts, because notwithstanding its less efficacy it is not quite harmless to the vine leaves.

Septoria Piricola, Desm. (spotting of the leaves of the pear).—Duggar used potassium sulphide with success, but found it less efficient than bouillie bordelaise.

Cladosporium fulvum, Cooke (tomato disease).—The mycelium, which extends between the cells of the parenchyma, cannot be reached, but the conidiophores may be destroyed. Liver of sulphur acts better than sulphur in this instance (Mohr).

Glœosporium frutigenum,[2] Berk. (bitter or tardy rot of fruit).—To prevent this, Galloway and Nijpels spray the apples before maturity, in August, with a 0·4 per cent. solution.

Fusicladium dentriticum,[3] Fuckel (apple scab), *Fusicladium pirinum*, Fuckel (spots of the pear).—Goff found that on apple-trees frequently sprayed with 4 per cent. solutions of liver of sulphur from the birth of the leaves, and renewed after each heavy rain, the amount of diseased apples is appreciably diminished.

Use against Insects.—Potassium sulphide may be used as a caustic against delicate insects. It also destroys the tissues protecting grubs.

[1] ALTERNARIA BRASSICÆ F NIGRESCENS *Roasting (Grilling) of the leaves of the melon.*—In the months of August and September when great heats are followed by rains the leaves of the melon are seen to dry up and brown. The fungus develops rapidly on the leaves with small yellow spots; as they get larger these spots end in big maroon spots which cover the whole leaf.

[2] GLŒOSPORIUM FRUTIGENUM (bitter rot of the apple).—This disease, prevalent in America and in England, is characterized by brown spots which are produced on the green apples and are covered by black dots, the pycnides of the fungus.

[3] FUSICLADIUM PIRINUM (pear scab, pear holes). *Fusicladium dentriticum* (apple scab, holes of the apple).—These two fungi are very analogous, and do the same damage, the one on the pear-tree, the other on the apple-tree. The *Fusicladium pirinum* attacks the leaves, branches, and fruits of the pear-tree. Numerous dark spots appear on the leaves which become pulverulent and of a black olive-green. *Fusicladium dentriticum* produces black velvety olive-green-covered spots on the leaves of the apple-tree, on the fruits brown or dark spots, sometimes isolated, sometimes confluent.

Acridides.—Dubois observed the great sensitiveness of grasshoppers (Locusta) and their eggs to potassium sulphide These eggs touched by solutions of potassium sulphide do not hatch. Watering the soil with potassium monosulphide on the spot where the Acridides have laid their eggs may suffice to impede the invasions of the *Acridium migratorium* so formidable in Algeria.

Eriocampa adumbrata, Kl. (the pear-tree saw-fly).—Taschenberg recommends powdered fresh liver of sulphur spread like sulphur on the trees. Solutions of the sulphide are used with success against the caterpillar protected by a silky tissue which render them inaccessible to ordinary aqueous insecticides. Potassium sulphide by its caustic action softens and finally decomposes the tissues, and penetrates to the caterpillar which then dies owing to the sulphuretted hydrogen disengaged.

Cochylis ambignella, Hubn. (cochylis of the vine).—Schmidt-Achert recommends as very efficacious against this caterpillar a 2—5 per cent. solution of liver of sulphur sprayed on the flowers and on the grapes; Schafer, on the other hand, did not obtain good results by this treatment.

Hyponomeuta Malinella, Zell (hyponomeute of the apple-tree).—Bach found a bouillie made with 1200 grammes of soft soap and 200 grammes of liver of sulphur in 100 litres of water (say 12 lb., and 2 lb in 100 gallons of water). This bouillie can be used with success against all caterpillars that live in company in a spun refuge.

Tingis Piri, Fl (Tigre du Poirier).—Montillot recommends two or three coats with the brush in winter, at intervals of a fortnight, on the branches and trunks of pear-trees with a preparation made thus: 2 lb of potassium monosulphide is dissolved in the requisite amount of water; it is withdrawn from the fire and 2 lb. of flowers of sulphur gradually added.

Plant-lice.—Moss recommends a mixture of soap and liver of sulphur against lice in general Thumen regards $2\frac{1}{2}$ per cent. solutions of potassium sulphide as good. The phylloxera is absolutely refractory to the action of potassium monosulphide.

Phytoptides.—The acari, which by irritation of the tissues of the plant produce degeneration of the latter, become manifest by felt-like growths known as *erinoses* or by peculiar swellings of bright-coloured tints as is seen on the pear when it has the Cloque (brown rust), may be destroyed by the sulphides. Emulsions containing 3—4 per cent. of sulphur must be used at the moment when the acari have not yet produced the excrescences which protect them so efficaciously. Smith and Williamson advise to treat chiefly the *Eriophyes Piri*, Pgst., *Phytoptus Piri*, by two sprayings, one before the opening of the buds, and the second after collecting the fruit, or even spraying with a concentrated emulsion in winter followed by a weaker one after plants have come into leaf.

Potassium Chloride (Muriate of Potash), KCl, **Potassium Sulphate**, K_2SO_4.—**Natural Occurrence**.—Potassium chloride is found (500 grammes per cubic metre) in sea-water. Potassium chloride and sulphate of potash form vast underground deposits at Stassfurth in Prussia and at Kalusy in Galicia. In these mines the different salt beds have a different composition. Below vast deposits of rock salt

deposits rich in sulphate of potash are found under the form of triple sulphate of lime, magnesia and potash (*Polyhalite*), then sulphate of magnesia and potash (*Kainite*), and finally double chlorides such as *Carnallite*. Carnallite, for example, contains 16 per cent. of potassium chloride, 20 per cent of magnesium chloride, 25 per cent. of sodium chloride, 10 per cent. of magnesium sulphate, and 29 per cent of impurities. For agricultural purposes these salts are generally used in the impure state as brought from the mine. If it be desired to purify them and to obtain pure potassium chloride, the saline mass is pulverized and dissolved in large cast-iron steam-heated vessels. The solution is allowed to deposit, then decanted, and left to crystallize; the potassium chloride crystallizes, entraining with it a little magnesium and sodium chlorides which are removed by washing with cold water. If potassium chloride be treated with sulphuric acid, which is done commercially in cast-iron vessels, hydrochloric acid is given off and potassium sulphate formed.

Properties.—Potassium chloride is very soluble in pure water 320 grammes dissolve in 1 litre of water at 10° C., 570 grammes in 1 litre at 100° C. Potassium sulphate is less soluble, a litre of pure water dissolves 84 grammes at 0° C. and 260 grammes at 100° C.

Action on Plants.—Potash is a necessary plant food. In soils where potash is quite absent plants languish and finally die before maturing their seed. Such soils are rare. They are such as contain a large proportion of limestone, peat, or sand. Potash may be given to the plant as potassium chloride as well as the sulphate or nitrate. The crude salt from the mines is generally used for the purpose. If soil be dissolved by aid of sulphuric and hydrofluoric acids, and if the potash which it contains be isolated, enormous amounts are found per hectare. The German agronomists calculate this amount at 30—40 tons per hectare (12—16 tons per acre) Berthelot found 35 tons at Meudon (14 tons per acre) and Dehérain 32 tons at Grignon (12 8 tons per acre). This potassic mass is not in a state of soluble chemical combination, but it may be dissolved by the acid juices of the roots which it appropriates in sufficient amount. When potassic manures are added to soils of this nature, and they form the great majority, no benefit accrues to the plant, and the spots where they are applied cannot be recognized, no increased yield being obtained. Potassium manures are only useful as a supplementary material when the soil does not contain it in any form. Then its influence makes itself felt especially when the crop is sustained by other chemical manures such as sulphate of ammonia, nitrate of soda, and superphosphate. Farmyard dung, which contains 5 kilogrammes (11 lb.) of potash per ton, suffices with the (potash) salts contained in the soil to meet the requirements of agriculture. The belief in the great efficacy of potash salts in all soils, established by Liebig, has not been confirmed in practice. An excess of potash salt may, on the contrary, be injurious to certain plants. Heinrich was the first to observe the injurious effects of certain salts, such as potassium chloride and magnesium chloride, nitrate of soda and sulphate of ammonia on adventitious plants. Steglich has specially studied the action of potassium chloride on farm crops with the following results :—

TABLE XVIII.—*Showing the Action of a 30 per cent Solution and a 15 per cent Solution of Potassium Chloride (Muriate of Potash) on Farm Crops*

Crop.	30 per cent solution	15 per cent solution	Crop.	30 per cent solution	15 per cent solution
Grain.	Injurious fleeting	Disappears in 5–8 days	Lupin . .	Deadly	Deadly
			Flax .	"	"
Beets .	Nil	Nil	Mustard	"	"
Potatoes	Deadly	Deadly	Charlock .	Very injurious	Nil
Peas .	"	Slight	Sorrel .	"	Slight
Haricots .	"	"	Polygonium	Deadly	Nil
Trefoil .	Nil	Nil	Horse-tail .	Injurious	"

On the other hand, a 6 per cent solution of kainite has no injurious effect on the most tender part of the plant.

Use.—As Pickle for Seed-Corn Smut.—G. Arieti tried to disinfect seed-corn against smut by steeping it for twenty-four hours in a 0·5 per cent. solution At that strength potassium sulphate has no injurious action on the germination of the grain, but neither is its action on the spores very pronounced. A 2 per cent. solution renders the spores of *Tilletia* (bunt) inactive, but the seed already suffers G. Ville, having observed that a want of potash in the soil seems to favour the development of the *Phytophthora infestans*, de By (potato disease), recommended the use of potassic manures to combat it in a preventive manner. Care must be taken, however, not to use larger quantities than 600 kilogrammes per hectare, say 528 lb. per acre, for at that dose potash salts diminish the yield in starch. These salts are also employed against phanerogamic parasites, such as dodder.

Cuscuta epithymum, Murray (dodder of trefoil and lucerne) —Their sensitiveness to metallic salts is very great, and these parasites may be easily destroyed by watering the fields with such solutions. In the same way as the sulphates of iron and copper, green and blue vitriols, which give good results, the sulphate of potash may also be used. Vesque recommends to dust with this product in a heavy morning dew the plots invaded by dodder. Next morning, after this treatment, the fields of trefoil and lucerne present a lamentable appearance; all the plants are brown and look as if burned, but the effect of sulphate of potash on *Leguminosæ* is only fleeting, and in eight days these plants have resumed their vitality, whilst the dodder is destroyed to such an extent that it does not reappear the following year. The dose to use is from 200—250 grammes per square metre, say 7—8 oz per square yard

Equisetum arvense, L. (meadow horse-tail).—This plant, which contains aconite, is injurious to cattle. Tacke advises, to free crops infested with it, to water them with a concentrated solution of potassium sulphate; the gramineæ can resist this treatment, whilst the horse-tails die.

Heterodera Schachtii, Schm. (nematode of the beet).—As a sequel to Liebig's researches, concluding that potash is a necessary food of this plant, it was observed that potash salts used in beet growing, up to a certain dose, remedied the exhaustion of the soil. The general

opinion was that such salts acted by their nutritive properties and replaced the potash removed by the beet But after it was found that the exhaustion of the land by this crop was due in great part to an excessive growth of small worms, *nematodes*, Hollrung tried the action of potash salts on their larvæ He remarked that the latter, more sensitive than the adults, died in forty-eight hours in a 1 per cent. solution of potassium chloride and in three hours in a 5 per cent solution. Potassium sulphate is less active in a 1 per cent solution as it takes ninety-six hours' immersion to destroy the larvæ, and has the same toxicity as potassium chloride in a 5 per cent. dose To succeed, the dose used must be considerable, instead of using pure sulphate, the double salts from the mines, kainite or carnallite, are used, but these are less active than the pure salts Hollrung has observed that in big doses these salts are unfavourable to the formation of sugar in the beet. There are no great advantages in using potassium chloride or sulphate in heavy doses to remedy the exhaustion of the land, for the effect is somewhat illusory. This practice has moreover been abandoned since, as the outcome of Aimé Gerard's researches, arable land may be sterilized by large doses of carbon disulphide.

Agriotes lineatus, L (striped wire-worm).—Comstock and Slingerland ascribe insecticide properties to potassium sulphate against the adults Smith regards a 12 per cent. solution of kainite as an excellent insecticide. But Marlatt, who used big doses of kainite, against wire-worm (Elaterides, click beetles), got no appreciable result. Mineral manures such as potash salts injure certain parasitic larvæ, *e g.* .—

Lachnosterna fusca, Frohl (May beetle); *Lachnosterna arcuata*.[1]—; Chittenden found kainite very active. Possibly the larvæ of the Elaterides which are very mobile flee from soils which have been treated with big doses of potash manures. Opinions are too contradictory to admit that potash salts kill them.

Agrotis segetum, W V. (common dart moth)—The grey worm, the caterpillar of this butterfly, is driven off or destroyed by watering the infested spots by a 12 per cent. solution of kainite.

Jassus sexnotatus, Fall.—Steglich uses kainite in a composition to combat this grasshopper: kainite 10 lb., carbolic acid 1 lb, soft soap 10 lb, in 100 gallons of water.

Snails.—Kainite is a specific against snails (Taschenberg).

Nitrate of Potash, KNO_3.—**Occurrence.**—Nitrate of potash, or saltpetre, occurs in nature, it is found in the great plains of China, India, and Egypt. It is extracted by removing the nitrated earth for a few centimetres and lixiviating it. The liquor is then run into large basins and evaporated in the sun.

Chemical Preparation.—By double decomposition of sodium nitrate and potassium chloride. By hot concentration of the solution the sodium chloride formed crystallizes, whilst the saltpetre, much more soluble when hot than common salt, remains in solution and does not deposit until after cooling.

Properties.—Saltpetre is very soluble in water, 10 gallons of water dissolve 15 lb. of saltpetre at 9° C., 85 lb. at 15° C., 246 lb. at 100° C

[1] LACHNOSTERNA ARCUATA (red cockchafer), the larva of which gnaws the roots of vines and strawberry plants in America.

(212° F), 335 lb at 118° C At a great heat [igneous fusion] saltpetre is a powerful oxidizing agent

Action on Plants.—Potassium nitrate, like potassium chloride, is a plant food, and what has been said concerning potash salts applies to potassium nitrate [1] Concentrated solutions injure plants.

Action on Fungi and their Spores.—Wuthrich's researches on the action of metallic salts on the spores of fungi also include potassium nitrate. The growth of the conidia of *Phytophthora infestans*, de By., is not stopped by a 0 1 per cent solution, but the formation of zoospores is prevented. The growth of the conidia is not hindered until a 1 per cent solution is used The zoospores are at once killed by this solution. The spores of *Peronospora viticola*, de By , are a little more sensitive. A 0 01 per cent. solution hinders their growth a little, with a 0 1 per cent. solution the conidia cannot form zoospores Their motion is slackened, and after fifteen hours none reach their normal growth, a 40·4 per cent. solution interferes with the growth of *Ustilago Carbo* (smut), a 50 5 per cent. solution stops it. A 50·5 per cent. solution lowers the vitality of the spores of *Puccinia graminis*, Pers., but they are only killed with a 101·1 per cent. solution A 101 per cent. solution does not destroy the vitality of the spores of *Claviceps purpurea* (ergot), Tul. Nitrate of potash therefore, even in strong doses, is deficient in real anti-cryptogamic properties It has no toxic action, but merely exerts an unfavourable effect on the development of the spores by producing plasmolysis Like many substances, potassium nitrate acts as an astringent when it is used in concentrated solution. As such it may prevent all cryptogamic evolution, but that is all its effect If the spores, the growth of which has been momentarily suspended, are washed and replaced in good conditions, they generally develop normally

Use.—*Ptereneus ribesii*,[2] Scop. (gooseberry and currant saw-fly); *Abraxas grossulariata*, L (the magpie moth) - Taschenberg uses against these two gooseberry pests a spray of a 1·2 per cent solution of nitrate of potash

The disease caused by *Botryodiplodia theobromae* in cocoa plantations can often be cured by applications of nitrate of potash, and examination of the plants after this treatment shows that the fungous hyphæ are absorbed by the host.

Carbonate of Potash, K_2CO_3.— Preparation.—The impure commercial potash is obtained by incinerating terrestrial plants. This incineration is done where there are many forests and where the means of transporting wood are difficult. The ashes obtained, which do not contain more than 5—20 per cent of carbonate of potash, are washed in casks and are exhausted after three or four washings. The collected liquors are evaporated and yield the salt which calcined in contact with air furnishes commercial potash, consisting mostly of carbonate of

[1] *Translator's Note* —But the nitric acid is the predominating agent of potassium nitrate, and as a plant food puts it beyond comparison with other potash salts, the phosphate excepted.

[2] *Ptereneus ribesii* (gooseberry saw-fly).—The larvæ of these saw-flies attack different species of gooseberries, entirely deprive these shrubs of their foliage, and thus prevent the development of the fruit. During May the larva which is adult descends into the ground to turn into a grub. After three weeks the insect hatches and forms a new generation.

potash with a small amount of potassium sulphate and chloride Other sources are, wool yolk, beet sugar molasses and cement dust Large amounts of potash are produced in Russia by the incineration of sunflower stalks

Properties.—Deliquescent. Dissolves in its own weight of water Reaction strongly alkaline.

Action of Carbonate of Potash on Plants.—Used in agriculture carbonate of potash by its alkalinity plays the *rôle* of lime, *i e*, it corrects the acidity of the soil and utilizes the nitric ferments which can only work in a slightly alkaline soil. The nitric acid so formed increases the crop. Carbonate of potash can thus greatly alter the flora of an acid meadow. The reeds and rushes of the acid land disappear to the benefit of the useful *Gramineæ* and *Leguminosæ* This sensitiveness of plants belonging to the *Cyperaceæ* and the reeds has been often remarked, and this product is utilized to destroy them. Noffray spreads wood ashes on meadows in wet weather or after a strong dew, the reeds and the rushes are burned and the *Leguminosæ* grow rapidly The injurious action of carbonate of potash is not limited to these plants alone, it is very decisive on dodders, mosses, and lichens The first are destroyed by spreading wood ashes on the clover fields in dry weather and watering afterwards. The result is satisfactory, but it cannot be compared to that got with green vitriol, for there often remains after treatment some immune parts which contribute to the propagation of the disease. Carbonate of potash may replace lime against mosses and lichens Sorauer replaces the common process of liming the trunks of trees by coating them with a solution of 15 lb. of carbonate of potash in 15 gallons of water. This treatment not only frees the tree from the parasites sheltered under the fissures of the bark but does not colour the tree white like lime.

Action on Fungi.—Alkaline carbonates have no toxic action on spores of fungi, but at a certain strength they impede their growth. Tillet who observed this action found it sufficient to guarantee the seeds of black wheat. Disinfection by the lye from wood ashes has given appreciable results.

Plasmodiophora brassicæ,[1] Woronine (finger and toe)—As a preventive, Nijpels waters with carbonate of potash against the finger and toe so as to kill the spores of the myxomycetes and prevent infection of young plants.

Action on Insects.—Soft-skinned insects are generally very sensitive to alkaline substances and may be combated therewith. Soft soap and lime are of great service; carbonate of potash acting similarly has been recommended by some observers.

Crioceris asparagi, L. (the asparagus beetle).—The larva of this Coleoptera is very delicate and may be destroyed by spraying with the lye from wood ashes.

[1] PLASMODIOPHORA BRASSICÆ (finger and toe)—This disease is characterized by excrescences on the roots It causes stoppage of growth and kills the plant This disease may attack all varieties of cabbage, as well as beets, turnips, and radishes The fungus which accompanies this disease belongs to the family of Myxomycetes, fungus consisting of a protoplasmic mass, the plasmodium, which changes incessantly in shape and which moves after the style of the lower organisms, the amœba

Haltica (ground flea beetle).—To prevent these voracious Coleoptera from gnawing the young plants growing in the fields in the spring, Montillot spreads wood ashes on the seed beds It is chiefly against the different species of plant lice that carbonate of potash has been found useful.

Aspidiotus perniciosa (San José louse) —Marlatt made numerous attempts to destroy this apple bug, so formidable in America, and obtained with 24 lb of lye in 10 gallons of water, 85 per cent lice killed, with 12 lb. 75 per cent., with 6 lb. 50 per cent., with 3 lb 20 per cent. Carbonate of potash in itself acts injuriously on the lice, and as it is at everyone's disposal it may be tried in certain cases But it will act more surely if it be used as an aid to certain toxic substances, petroleum, for example Alkaline products, in fact, act on the mucus and the chitin so as to let the toxic substances reach the parasite and act on it more rapidly.

Wood ashes are also utilized to kill slugs, using preferably that from lime-kilns, as it still contains lime, the action of which aids the carbonate of potash. After a rain in the evening the ashes are spread broadcast on the seed beds of whatever nature, it exerts no injurious action on the plant but kills snails instantly on touch. It is well to water the plants next morning and recommence the treatment after sunset, In vineyards where slugs are dreaded vines are heavily dusted with ashes.

Potassium Sulphocarbonate, K_2CS_3,H_2O.—**Preparation.**- By agitating potassium monosulphide K_2S, with an excess of carbon disulphide. If a pure product be not desired liver of sulphur may also be used.

Properties.—Carbon disulphide acts as an acid towards alkaline sulphides and forms compounds therewith analogous in constitution to the alkaline carbonates, K_2SCS_2.

But these compounds are unstable, the moisture and carbonic acid in the air decompose them thus—

$$K_2CS_3 + CO_2 + H_2O = K_2CO_3 + CS_2 + H_2S$$

into alkaline carbonate, carbon disulphide, and sulphuretted hydrogen. Organic acids act in the same way. This decomposition goes on slowly in the air and in the soil, according to the moisture of the surrounding media and the richness in carbonic acid. The dry crystals contain 38 per cent. of carbon disulphide and can disengage 17 per cent. of sulphuretted hydrogen; 100 grammes of 40° Bé. commercial solution, which tests 55 per cent. of pure potassium sulphocarbonate, can give off on decomposition 20 per cent. of carbon disulphide, say 6 litres, and 9 per cent. of hydrogen sulphide. Potassium sulphocarbonate is in the solid condition a yellow crystalline very deliquescent body. But it is very difficult to obtain in that form, and the commercial article is liquid and marks 35—40° Bé. It is soluble in water in all proportions. [Alkaline sulphocarbonates treated by hydrochloric acid, then taken up immediately by water, yield a reddish-brown insoluble liquid which represents sulphocarbonic acid; it is used in therapeutics. It readily decomposes into CS_2 and H_2S. The sulphocarbonates which chemically contain carbon disulphide have no analogy with the sulphide mixed with tar, vaseline, oil, or soap, the use of which has been proposed to replace the pure sulphide.]

Action on Plants.—Sulphocarbonate when concentrated is a violent plant poison The two gases [CS_2 and H_2S] which it liberates are likewise poisons, but their action is less energetic than that of the sulphocarbonate itself Trials on healthy vines in 3-litre pots at different seasons of the year show that the vine is more sensitive in summer during the activity of the sap than in winter. Thus in August, vines do not stand a dose of 12 cubic centimetres of 40° Bé. with or without water, whilst a dose of 15 cubic centimetres may be given in winter, and even in April when already the vine has big buds. Now 15 cubic centimetres of sulphocarbonate of 40° Bé can only disengage 3 grammes of carbon disulphide and 1·35 grammes of sulphuretted hydrogen, quantities which are supported by the vine in similar conditions, especially in emulsion in water It takes more than 6 cubic centimetres of sulphide emulsified in 60 cubic centimetres of water to kill the vine at that period Young adventitious plants (*Mercurialis annuæ, Polygonum aviculare, Calendula arvensis, Borrago officinalis, Erodium cicutarium, Ictaria viridis*) vegetating in the open air were treated at end of August with 100 cubic centimetres of sulphocarbonate of potassium or sodium of 45° Bé., reduced so as to make 2 litres of mixture, and spread in five holes in a square of 20-inch side, the plants only suffered in the immediate neighbourhood of the holes Haricots planted in pots containing 2 litres of soil resist perfectly when watered with 250 grammes of a 2 per cent solution of 45° Bé. potassium sulphocarbonate. Now, in practice, such strong doses are never used against insects. The toxic effect of potassium sulphocarbonate on plants is therefore almost negligible, whilst the dose is always poisonous to insects in a 0·0005 per cent solution.

Action on Fungi.—Like carbon disulphide potassium sulphocarbonate in strong doses exerts an injurious action on the mycelium of fungi and their spores. Dufour and Mouillefert tried this compound to replace carbon disulphide against root blight, *Dematophora necatrix*, Hartig. They did not, however, obtain the good results which they anticipated Dufour only registered 15 per cent of cures after treating the stocks of vines suffering from the blight by a 2 per cent solution at the rate of 3—5 litres per stock. It is true, that in these trials Dufour is far from having fed into the soil a dose of 150—200 grammes of carbon disulphide per square metre, as is the case in the treatment of root blight by carbon disulphide, for the 100 grammes of liquid sulphocarbonate used in this case only contained 15 grammes of sulphide. Sulphocarbonates cannot replace the sulphide in the treatment of root blight, for they are much dearer. It is only when the dose of sulphide is minimum, as in the case of some insects, that the sulphocarbonates present real advantages over carbon disulphide.

Action on Insects.—Sulphocarbonates, owing to their composition, are almost equally as efficient as potassium cyanide The most dilute solutions have a manifest and rapid action on insects. Mouillefert examined very exactly the limit of action of sulphocarbonates used against the phylloxera in different ways

1. *By Contact.*—By dipping the insects into dilute solutions, 1 in 200 of sulphocarbonate of 38° Bé., the insects were found dead in a

quarter of an hour; in 1 in 500, in one hour, in 1 in 1000, in one hour fifteen minutes, in 1 in 5000, one hour; in 1 in 10,000, two hours fifteen minutes; in 1 in 100,000, in twenty-four hours. In a blank flask only containing water the insects were not dead in twenty-four hours. The potassium sulphocarbonate of 38° Bé used in these trials not containing 50 per cent. of dry sulphocarbonate, it may be said that the action of this product is deadly to the phylloxera in twenty-four hours in a 1 in 200,000 solution, say 0 0005 per cent of dry salt

2 *By the toxic vapours* disengaged by the decomposition of the sulphocarbonates. In a 2-litre flask with moist sides into which ½ cubic centimetre of sulphocarbonate of potash of 40° Bé had been run, the phylloxeras of an infested root suspended in this flask were killed in three hours. By running in 4 cubic centimetres of this product the insects were killed in half an hour. Now ½ cubic centimetre contained 0 354 of dry sulphocarbonate capable of emitting by decomposition 0 14 gramme of carbon disulphide, or 40 cubic centimetres, and 0 06 gramme of sulphuretted hydrogen, or 40 cubic centimetres of gas, giving a total of 80 cubic centimetres of poisonous gas It may therefore be concluded that ½ cubic centimetre of sulphocarbonate is capable of producing in 2 litres of air an atmosphere with 4 per cent. of toxic gases

In trials with $\frac{1}{10}$ cubic centimetres of sulphocarbonate, or with 100 cubic centimetres of a 0·1 per cent. solution, capable of producing 16 cubic centimetres of poisonous gas, and consequently an atmosphere of 0 8 per cent., the insects were killed in twenty-four hours Now it is admitted that sulphuretted hydrogen destroys the phylloxera in twenty-four hours when the air contains 1 per cent. of this gas, and carbon disulphide when the atmosphere contains 0·5 per cent. of its vapours It has been seen that the sulphocarbonate of potash disengages the same volume of these two gases. It follows that a mixture of equal volumes of sulphuretted hydrogen and carbon disulphide in the gaseous state would kill it in twenty-four hours with a solution of 0·75 per cent. strength. The result obtained is thus appreciably the same as that found for sulphocarbonate of potash The mixture of the two gases produced by the decomposition of the sulphocarbonates kills the phylloxera in the same time as a mixture of the same qualities of these two gases acting simultaneously. But sulphocarbonates do not act only when they enter into decomposition, their solutions are in themselves powerful insecticides. Whilst both gases produced by the decomposition do not kill the phylloxera except at 0 0015 per cent. the sulphocarbonates in solution kill at 0 0005 per cent. Sulphocarbonates may thus be regarded as the most powerful of disinfectants, their aqueous solution being three times more powerful than sulphuretted hydrogen gas and carbon disulphide. Owing to this property, alkaline sulphocarbonates may be used to distribute through the soil substances highly poisonous to insects. There is no difference in the action of the different salts of sulphocarbonic acid, potassium, sodium, or calcium salts, but the former are generally used because they possess the advantage of carrying into the soil a certain amount of potash, which, in certain circumstances, may contribute to the rapid reconstitution of the damaged root system. The doses used in the

laboratory to kill the phylloxera are not those which are of use on the large scale, because many causes contribute to reduce their efficiency. The doses tried by Mouillefert were at first very strong, and killed the vine treated as well as the parasites The soil was watered from small vats near the stocks with a solution of 400 cubic centimetres of sulphocarbonate of potash of 38° Bé in 5 litres of water, then with 8 litres of pure water In other cases he used 220 cubic centimetres of sodium sulphocarbonate of 45° Bé dissolved in ½ litre of water, distributed in four holes 60 centimetres deep placed in a radius of 35 centimetres around the stocks The dose of 20 cubic centimetres of sulphocarbonate of 33° Bé sufficed to kill the phylloxera without injuring the vine, but it is preferable to use per stock 50—80 centimetres of sulphocarbonate at 37·2° Bé dissolved in 10 litres of water to obtain complete success.

Use.—Sulphocarbonates were examined so as to be utilized in vine-growing in the destruction of the phylloxera. The results obtained by *sulphocarbonation* led to this treatment being tried on other insects, on which it has also given good results

Phylloxera vastatrix, Planch. (phylloxera of the vine) —*History.*— In 1874, Dumas proposed the sulphocarbonates for the destruction of the phylloxera, indicating at the same time a practical method for their manufacture The Department of Agriculture and the *Académie des Sciences* entrusted two delegates, Cornu and Mouillefert, to make the necessary experiments to determine if the predictions of the learned chemist would be realized. Mouillefert made numerous experiments at the Cognac Viticultural Station, and was able to conclude that the sulphocarbonates, and especially potassium sulphocarbonate, were marvellous insecticides and also the best remedy against the phylloxera. In his remarkable research on the chemical products proposed for the destruction of the phylloxera he places the sulphocarbonates in the first rank of efficiency, and declares them to be alone capable of keeping a vine attacked by the phylloxera in a thriving condition, and to regenerate it if weakened by the disease.

In numerous experiments on vine stocks placed in different conditions of soil, age, and cultivation, the sulphocarbonates always effected an improvement. Those of which a part of the radicles was attacked were, after a year's treatment, finer plants than the non-diseased stocks The stocks still more badly diseased and almost in the last extremity were appreciably improved and did not die like the untreated blanks.

Mouillefert in 1876 published the conditions which it is indispensable to observe to secure good results by this treatment. The useful application of alkaline sulphocarbonates to the cure of the vine requires · (1) That all the infected surface be treated. (2) That the poison be injected deep enough to reach all the phylloxera The best method to secure perfect diffusion in the soil is to use water as the vehicle. The amount used may be greater, or less, according to the state and conditions of humidity in the soil, and according as it may be expected to rain, or not, but water cannot be completely suppressed. The more water added, the more complete the diffusion and rapid the action. The amount of sulphocarbonate required to treat a square metre to a depth of 80 centimetres, 31 2 inches, which gives 800 litres,

say 1 cubic yard, of soil, is 30—40 cubic centimetres, 1—1⅓ fluid oz, which is comparatively very little. Without the aid of water it would be very difficult to distribute this small volume on the surface of the soil and equally impossible to cause it to descend to a sufficient depth to kill all the insects unless the soil be very permeable or rain falls at a propitious moment, which is exceptional In all cases the direct use of water suffices if the quantity be abundant, whether the soil be compact, stony, or permeable, diffusion is always perfect Alkaline sulphocarbonate solutions of 1 in 10,000 and even 1 in 20,000 being still poisonous in cultivation on the large scale, too great dilution need not be feared, in rendering diffusion more perfect, to make the remedy impotent. The best method of using sulphocarbonates consists in making flat receptacles in the soil, round the foot of each vine, and there distributing the poison. For this purpose 500 kilogrammes per hectare (440 lb. per acre), say 50 grammes per square metre, are diluted in 350 times its weight of water. After having poured the solution into the excavations it is well to pour on a little water to cause the poison to penetrate more deeply When all the water is absorbed by the soil, the ground is put back into the pit and tramped down under foot. Sulphocarbonates may be used at any time of year, for the small dose has no effect on the plant, but it is preferable to use them whilst the sap is at rest. The water required to carry the poison into the depths of the soil being sometimes an obstacle to its use in many districts, the most convenient time for the application of sulphocarbonates is, then, that when rain is most abundant during winter, when the soil is already saturated with moisture. For small or medium scale cultivation, the best plan consists in placing the amount of sulphocarbonate required for a stock, say 50 grammes (1¾ oz), in a 10-litre (2 2 gallon) watering-can, then to pour into each pit the entire contents of this watering-can, and afterwards pour an entire watering-can full of water on each stock. But it is preferable when possible to make a dilute solution in a large reservoir, and to draw out with the watering-can the amount required for each stock. On the large scale, Mouillefert and Hembert have designed plant intended to bring the water required for the treatment into vineyards It consists of a steam engine, working suction and propelling pump which can send the water several kilometres, and to a height of 100—150 metres (328—492 feet) The pump, placed near a river or a lake, sends the water into a distributing channel forming a network of ramifications through the vineyard The channels of the third order end in metallic vessels of 350—400 litres (77—88 gallons) in which the sulphocarbonate is dissolved; the workmen there draw the amount of insecticide required, and spread it with the watering-can around the stocks. With good organization the workmen need not carry the water more than 10 metres, say 33 feet. A man can then spread 1500—1800 litres, say 330—396 gallons, of water an hour round the vines. By this ingenious process, vines far from a source of water may be treated. But owing to the large amount of water required, which is 150,000 litres per hectare, say 60,000 litres (13,200 gallons) per acre, being awanting in many districts, this treatment has not been adopted everywhere. Its use also finds a drawback in the fact

that the cost of sulphocarbonating is greater than sulphuring. It is true that it brings potash to the value of 50 francs per hectare, on to the land, but that is only really useful in districts where potash is deficient Sulphocarbonates have therefore their place only in rich vineyards like those of Champagne, Burgundy, and Bordeaux They should be preferred to carbon disulphide, the more so as they are much less dangerous for the vine As Foex justly remarks, it is a process to use in *de luxe* vineyards There are in France vineyards that have been submitted to this treatment for fifteen years, and still in good condition. In France there are hardly more than 10,000—12,000 hectares (25,000—30,000 acres) treated annually by sulphocarbonates, and since the carbon disulphide treatment has been better studied this figure has a tendency to diminish, for the carbon disulphide treatment, like the sulphocarbonate, being annual the small doses of sulphide used in such conditions are not prejudicial to the vine and enable it to be kept in a good state of production. Unfortunately, whatever care be taken in applying these substances there will always be a certain number of phylloxera which escape the toxic action. If, theoretically, the sulphocarbonates are capable in small doses of entirely destroying the insects on the roots, it is not so in practice even in much stronger doses; different causes prevent the result from being so complete. But by the treatment the number of the phylloxera is so reduced as to enable the root hairs formed during the fine weather not to be entirely destroyed, and for the plant to nourish itself on the revival of vegetation If the evil be not entirely removed it no longer forms an obstacle to the vine maintaining its vigour. The important point is to diminish the parasites, so that the vine may live with them without the crop suffering The use of water as the vehicle of the sulphocarbonate being the great obstacle to the propagation of this marvellous insecticide, it has been tried whether mixtures with slaked lime would not likewise bring about a uniform distribution of the sulphocarbonates in the soil. It was Dumas who advised Mouillefert to try these mixtures, hoping that the lime, before its transformation into carbonate, would absorb the carbonic acid of the air and prevent the sulphocarbonate decomposing rapidly. In this way a powder would be got easy to spread in the soil at the foot of the stocks, which would preserve the alkaline carbonate intact whilst waiting for rain to carry it into the neighbourhood of the infected roots Mouillefert, therefore, mixed 500 cubic centimetres of sulphocarbonate of potash of 37° Bé with 1·2 kilogrammes of lime in powder and spread this mixture in winter at the foot of five stocks, previously stripped to the big roots on a radius of 35—45 centimetres, the earth was then put back into the holes A fortnight later after a series of heavy rains the roots were examined; on all the top roots the insects were dead, but on the roots more than 40 centimetres (say 6 inches) the insects were not found dead until two months afterwards. Success would have been complete if it had not been that on the roots beyond the stripped radius the phylloxera were still living According to the predictions of Dumas, the use of sulphocarbonate in these conditions may suffice, provided the mixture be spread all over the vineyard. To attain this object the

proportion of lime must be increased greatly, and a mixture of 500 kilogrammes of sulphocarbonate with 5000 kilogrammes of slaked lime applied per hectare of vineyard (say 440 lb and 4400 lb, 2 metric tons per acre). After spreading it would suffice to hoe the ground so as to mix it with the earth and protect it from contact with the air which would decompose it. From Laugier's experiments it would appear possible without hurting the vine gradually to extinguish the hotbeds of phylloxera infection, by aid of repeated mixed treatments of sulphocarbonate of potassium and carbon disulphide, applied opportunely and in suitable doses This process, much used in Switzerland and Italy, appears to leave nothing to be desired.

Disinfection of Vines and Graft Bearers.– Sannino advises for this purpose sulphocarbonate of potassium in 0·05 per cent solution; for disinfection to be complete immersion must last two hours. Dufour recommends for the disinfection of graft bearers coming from a phylloxera district the steeping of these in a solution of the following. sulphocarbonate of potash 0·5 per cent., soft soap 5 per cent.; pyrethra powder 1 per cent, tobacco juice 1 per cent.

Carpocapsa pomonella (*Pyrale du Pommier*) (the codlin moth); *Carpocapsa funebrana*,[1] Fr. (? *Carpocapsa nigricane*) (the red plum grub) —Montillot recommends watering the soil at the foot of the trees in autumn, after collecting the fruit, with a solution containing 1 per cent. of sulphocarbonate potassium

Cochylis ambiguella, Hubn. (cochylis of the vine).—Dufour tried to combat this insect by spraying with sulphocarbonate, but he did not kill the caterpillar. A bouillie containing 1 per cent. of sulphocarbonate and 3 per cent of soap destroyed the insects but scorched the buds, which browned and finally dropped off. A 0·1—0 05 per cent. solution does not injure the plant and kills all underground larvæ.

Formica (ants).—An excellent means of destroying an ant-hill consists in the use of sulphocarbonate A small trench is dug round the ant-hill and it is watered in the morning as far as possible, when the ants have not yet gone out, with a 0·5 per cent solution. Half a litre to a litre of this solution suffices to destroy an ant-hill. After absorption of the liquid it is well to beat the earth down.

Galeruca calmariensis (galeruca of the elm), *Galeruca alni* (galeruca of the alder).—Sulphocarbonates in solution applied in August destroy these insects, which are so injurious to the trees in our parks and public promenades.

Tipula oleracea (meadow tipula)—To destroy the larvæ of tipula, carbon disulphide may be replaced by spraying meadows and fields with a dilute solution of potassium sulphocarbonate Barthon, who recommends this treatment, advises to test previously the dose which will not injure the plants on which it is to be applied. A solution of 0·1 to 0·5 per cent. never injures plants and kills all underground larvæ.

[1] CARPOCAPSA FUNEBRANA *Pyralis of the Plum* (wormy plums, plum worms)—Small butterfly, 7 millimetres long, blackish with some spots and lines of a greyish-blue In July the female lays its eggs on the still green plum As soon as hatched the caterpillars penetrate into the fruit and remain there until maturity.

Xanthogenate of Potassium, C_2H_5OCSSK.—**Definition.**—This compound is the potassium salt of the ethylic ether of dithiocarbonic acid, OHCSSH.

Preparation.—By acting with an excess of carbon disulphide on absolute alcohol saturated with caustic potash. The crystals of xanthogenate of potassium formed abundantly are washed with ether.

Properties.—Xanthogenate or ethyl sulphocarbonate of potassium forms colourless or slightly yellowish needles, they are soluble in water, likewise dissolving in 5—6 parts of absolute alcohol. The decomposition of the aqueous solutions into carbon disulphide, ethyl alcohol, and potash begins at a temperature of 25° C. (77° F.), to be completed on boiling. Xanthogenate of potassium stops fermentation like carbon disulphide and coagulates albumen. Schwartz found that the action of its solutions on bacteria and ferments do not commence except at the temperature at which this salt decomposes, and that it only therefore possesses the disinfectant action of carbon disulphide. But this does not in any way detract from its valuable properties as an antiseptic, since carbon disulphide acts on bacteria in aqueous solution at 0·5 per cent. and that this product contains 47 per cent. of carbon disulphide.

Use.—Xanthogenate of potassium may be used in all cases where carbon disulphide and sulphocarbonate of potash have been found useful. Its solubility in water is greater than that of carbon disulphide and its stability in air more perfect than that of sulphocarbonate of potassium. Its properties would have assured it a much higher place in agricultural medicine if its price were not higher than similar compounds. Yet in spite of its high price xanthogenate of potassium is used in disinfection and enters into the composition of certain insecticides.

Phylloxera vastatrix, Planch. (phylloxera of the vine).—Dr. Koenig, director of the Agronomical Station of Nice, has made very extended trials of the action of this salt on phylloxera, and found that compared with carbon disulphide and sulphocarbonate of potash its value as a disinfectant of phylloxera-infected vines was greater and more certain. The eggs and phylloxeras are killed without exception by submitting them to the action of solutions of xanthogenate of potassium or to that of the vapours which its solutions emit on heating. To disinfect the roots Koenig recommends the use of aqueous solutions.

Schizoneura lanigera, Hausm. (woolly aphis).—Muhlberg recommends to combat the woolly aphis an insecticide which contains two most active substances, nitrobenzene and xanthogenate of potassium. Amyl alcohol 60 lb., soft soap 40 lb., nitrobenzene 2 lb., xanthogenate 1 lb., water 6 gallons. Knadolin in 2 per cent. solution kills the greater number of insects injurious to plants. To apply it the wounds and cankers caused by the American woolly aphis are coated with a solution of 1 part of this insecticide in 15 parts of water.

Potassium Cyanide, KCN.—**Preparation.**—An alkaline cyanide is formed each time that carbon and nitrogen come in contact at a high temperature with an alkali or an alkaline carbonate. Commercially potassium cyanide is prepared by submitting nitrogen or organic bodies rich in nitrogen to the action of carbon impregnated with potash and heated to redness. Prussic acid or hydrocyanic acid is

generated by the action of an acid on potassium cyanide.[1] The latter, however, does not give up all the hydrocyanic acid which it contains.

Properties.—Potassium cyanide crystallises in deliquescent cubes; it is found in commerce as fused white plates which must be kept out of contact with air because that decomposes it rapidly into hydrocyanic acid and carbonate of potash—

$$2KCN + H_2O + CO_2 = K_2CO_3 + 2HCN$$

The commercial product is never pure, it always contains a greater or less amount of carbonate of potash Prussic acid is a colourless, very volatile liquid having the odour of bitter almonds It is, like its salts, a deadly poison. The vapours given off by decomposition in contact with air kill the insects and animals which breathe it in a few minutes. Its action is the same in whichever way it be introduced into the body, by digestion, respiration, or introduced into the blood through a wound. A drop of hydrocyanic acid placed on the eye of a dog causes it to die in a few seconds a dreadful death. The respiration of the vapours of this acid induce giddiness, then death. The mortal dose for a man is 0 06 gramme, say 1 grain, of prussic acid and 0 15 gramme, say $2\frac{1}{4}$ grains, of potassium cyanide. According to Preyer, prussic acid acts through the compounds which it forms with the hæmoglobin and the oxyhæmoglobin of the blood.

Action on Plants.—All cyanogen compounds have a poisonous action on plants, but it is prussic acid which possesses this property in the highest degree. As far back as 1827, Goppert remarked that prussic acid prevented the germination of grain, and absorbed by the plant it killed it in one to three days. When a plant is watered with a dilute solution of cyanide the latter is absorbed and distributed throughout all parts of the plant by the sap; the leaves turn yellow, then brown, and the turgescence of the cells of the parenchyma is abolished. Perosino succeeded in injecting a very dilute solution of potassium cyanide into the trunk of a tree without hurting it, and after two days all trace of this product had disappeared in the sap, but the dose to be withstood was, it is true, infinitesimal. Berlese has shown that trees withstand these injections badly, even in small doses. Mouillefert made a very complete examination of the action of potassium cyanide on vines and adventitious plants.

Experiments made in July on Healthy Vines, variety Saint Emilion.—Placed in pots, each containing 3 litres of soil, three vine stocks were watered with (1) 170 milligrammes of cyanide, say a 0·142 per cent. solution; (2) 250 milligrammes of cyanide in 110 cubic centimetres of water, say a 0·18 per cent solution, (3) 500 milligrammes of cyanide dissolved in 180 cubic centimetres of water, say a 0 28 per cent. solution. In six days vine No. 3 was dead, that carrying No. 2 was greatly inconvenienced, and No 1 seemed to suffer. As will be seen from these results the substance is highly poisonous to the vine, as a dose of 0·008 per cent. of potassium cyanide in the soil kills this plant. Guerrieri estimates that a dose of 1 gramme suffices to kill an adult vine, and that it is impossible to kill the phylloxera by this method, the vine being as sensitive as the parasite. The fact that the phylloxeras of a vine treated with cyanide die mainly by the absorption

[1] See also Sodium Cyanide, above, p. 119.

of the poisoned juice, shows that this method of treatment must be as pernicious to the vine as to the phylloxera, Chittenden considers that it is impossible to treat all plants by hydrocyanic acid vapours to free them from pests; the acid may, however, be used without fear on *Davallia, Adiantum, Coleus, Viola, Rosa, Dianthus, Vitis,* and *Lycopersicum.* It is necessary to try each variety of plants to see if this method of treatment can be successfully adopted against the caterpillars without risk to the plants themselves.

Experiments made in July on Adventitious Plants.—The experimental ground was a square with side of 50 centimetres and contained young plants about fifteen days old (*Mercurialis annua, Polygonum aviculare, Amaranthus blitum, Borago officinalis,* and *Erodium cicutarium*), 500 milligrammes of potassium cyanide, dissolved in 400 cubic centimetres of water, say a solution of 0.125 per cent, was distributed in five deep holes of 15—20 centimetres. In the morning all the young plants were dead. After six days nothing remained alive but two stocks of *Borago* and one stock of *Erodium.*

Action on Fungi.—Few trials have been made. Hitchcock and Carleton immersed the uredospores of *Puccinia graminis* in a 0·1 per cent. and a 0·01 per cent. solution. The first solution prevented germination. The second had no effect.

Action on Insects.—Potassium cyanide, also the prussic acid given off from it in moist air, are insecticides of extraordinary power, an infinitesimal dose killing insects in a few minutes. Its action is more energetic than that of sulphocarbonate of potash, sulphuretted hydrogen, and ammonia. It acts on insects by respiration and through the stomach. Entomologists use it to kill the insects which they catch. Mouillefert submitted different insects to the action of this poison, especially the phylloxera, which he specially examined. One gramme of potassium cyanide was placed in a 250 cubic centimetre flask. The following are the results obtained with the different insects introduced successively into the flask: A butterfly died in four minutes, a dragonfly in ten minutes; an earwig in ten minutes, a plant louse is killed in less than two minutes; a stag beetle in four minutes; and a grasshopper in less than two minutes.

In America potassium cyanide is a specific for the destruction of certain plant lice; it is to be observed, however, that their eggs withstand doses usually sufficient to kill the adult insects. According to Coquillet it is chiefly the *Diaspines*, amongst which must be counted *Aspidiotes, Diaspis, Lecanium, Ceroplastes, Coccides,* which are most sensitive to prussic acid. Whilst almost all insects succumb when they respire a weak dose of prussic acid, there are some which are indifferent to this poisonous gas: these are certain *Coccinella*, the red spider (*Acarus telarius*) of Linneus (*Tetranychus telarius*, L.), the *Schizoneura lanigera*, Hausm. (woolly aphis); and some flies of the family of *Proctotrupidæ* of the genus *Alaptus.* The danger of the prussic acid treatment is an obstacle to its becoming general, the more so as there are less dangerous substances, which, in the same conditions, are of equal service. There are, however, certain cases where prussic acid is superior to these products. When it is a question of destroying one of those plant lice covered with a chitinous carapace, ordinary insecticides which do not reach the insect must be set aside, for

that reason. Emulsions of petroleum, amyl alcohol, benzine, and carbon disulphide, with soft soap, only yield imperfect results It is otherwise with prussic acid, its vapours, owing to their poisonous nature, can destroy the best protected insects through the respiratory organs, and as easy as any soft-skinned insect. In America the benefits of the substance have been recognized, and it is in constant use by farmers. By means of potassium cyanide used rationally in winter, fruit trees may be freed from all their parasites. In America apple-trees have been particularly the prey of the San José louse, but potassium cyanide, which has played in this case the *rôle* of carbon disulphide in the phylloxera invasion, has enabled this dangerous insect to be efficiently combated

Use.—In spite of its toxicity and the danger incidental to its use, potassium cyanide is in current use in certain countries, it is, in fact, the most radical and the cheapest means to destroy tree parasites. Cyanide can only be used in a closed space. Its decomposition is hastened by the addition of dilute sulphuric acid. This practice requires great precautions, because the prussic acid given off is as deadly to the operator as to the insects. When a greenhouse is not at disposal the operation is done under cloches for small plants, and under tents for trees. The latter are of packing cloth, impregnated with linseed oil and ochre, or wax. These portable tents are generally hexagonal in shape and must touch the ground on all sides, they are closed hermetically by beating down the soil on the edges of the cloth. In America they use exclusively large cubes with a wooden framework covered with packing cloth. In this manner trees as high as 20 feet may be treated. To disinfect a tree the tent is placed over it, and then a solution of potassium cyanide is run into a terrine to which dilute sulphuric acid is added, taking care to place this terrine quickly under the tent and to retire The following, according to Debray, are the quantities to use for 5 cubic metres of air: 30 grammes of 58 per cent potassium cyanide dissolved in 50 cubic centimetres of water, 35 grammes of sulphuric acid of 66° Bé. (168° Tw) diluted with 50 cubic centimetres of water According to Coquelin, the doses of potassium cyanide to use according to the size of the tree are as follow.—

TABLE XIX.—*Showing the Amount of Potassium Cyanide, Water, and Sulphuric Acid to Use in Cyaniding Trees of Different Height and Diameter.*

Height		Diameter		Potassium		Water, c c.	Sulphuric acid	
Metres	Feet	Metres	Feet	Grammes.	Grains		Grammes	Oz Av.
3	9·84	2·50	8·20	65	997	130	65	2·3
3·50	10·48	3·00	9·84	130	1994	250	130	4·5
3·50	10·48	4·50	14·76	250	3835	500	250	8·7
4·25	13·94	3·00	9·84	160	2454	350	160	
4·25	13·94	3·50	10·48	210	3222	500	210	
4·75	15·58	4·25	13·94	340	5216	750	340	
5·50	17·08	4·25	13·94	425	6521	850	425	

The action is complete in a quarter of an hour (Debray), three-quarters of an hour (Ritzema Bos), and five hours to destroy kermes (Reh). Johnson says that disinfection is complete in a very short time, and that with ten apparatus, 200 trees may be disinfected in a day, the operation lasting half an hour A method much in vogue in American consists in disinfecting the roots of young nursery plants as far as the crown. For this purpose all the trees are dug up, and placed in closed cupboards or chambers in which prussic acid is disengaged, 10,000 young trees can be disinfected in this way at a time. Dr. Koenig has introduced the practice of this style of disinfection at the Agronomical Station of Nice, where it is employed for vines, ornamental plants, as well as the branches of ornamental plants intended for exportation. Waite and Howard recommend for the disinfection of purchased trees hermetically sealed cupboards, in which they are enclosed for an hour in an atmosphere of prussic acid before replanting, although the majority of plants resist the action of these poisonous vapours it is preferable to operate during the repose of vegetation, for in that condition they resist stronger doses capable of destroying the parasites and their eggs. The action may be prolonged, and even last an hour. The result is only the more complete. Tuille recommends for the destruction of the larvæ of the cockchafer (*Melolontha vulgaris*, L.) to plough in colza or mustard during the flowering season along with a ton of gypsum or lime per hectare (8 cwt per acre). Amongst the poisonous gases given off in consequence of the fermentation of these plants is sulphuretted hydrogen, but also a certain amount of prussic acid

Scolytides.—In America prussic acid is regarded as an excellent substance for destroying the insects which dig galleries in the trunks of trees. It may be applied at the moment the *Scolytides* or the *Bostriches* attack the young trees

Wasps —Gardner recommends the use of a solution of 120 grammes in a litre of water (1·2 lb per gallon). A plug of waste is attached to a rod dipped in this solution, then introduced into the orifice of the nest of wasps. The effect is instantaneous.

Ptereneus ribesii, Scop. (gooseberry saw-fly) —The highly voracious larvæ of this saw-fly are destroyed in Canada by cyaniding, working under small tents as already mentioned. The gas acts in fifteen minutes. To destroy the butterflies injurious to cotton plantations, Mally plants haricot beans between the rows. As soon as the latter are in flower they are sprayed with a dilute solution of potassium cyanide. That kills the butterflies which settle on the flowers.

Carpocapsa pomonella (the codlin moth).—It is in winter that fumigation under a tent with prussic acid may be very effectual. The process is in common use in Canada.

Diplosis violicola, Coquillet (violet fly) —Chittenden advises treating the violet stocks with potassium cyanide, so as to kill the larvæ of this fly.

Phylloxera vastatrix, Planch. (phylloxera of the vine) —*Experiments on the phylloxera action by contact.*—A phylloxera-infected root was immersed for two minutes in a 1 per cent. solution of potassium cyanide; the phylloxeras and their eggs were all dead when it was lifted out.

Experiments on Phylloxera Fumigation.—Five milligrammes of potassium cyanide, yielding by decomposition 1·7 cubic centimetres of prussic acid vapour, were placed in a flask of 2100 cubic centimetres, then a phylloxera-infected root. When the action was complete the atmosphere of the flask consisted of 8 parts of prussic acid vapour per 10,000 parts of air. After fifteen hours there were no living insects. It follows that potassium cyanide is about ten times more poisonous than potassium sulphocarbonate, for it suffices for an atmosphere to contain 0·08 per cent. prussic acid gas to obtain the same result as with 0·75 of a mixture of equal parts of sulphuretted hydrogen and carbon disulphide, disengaged from potassium sulphocarbonate. Under a cloche 0·000240 of potassium cyanide kills plant lice.

Experiments on Phylloxera: Action by Poisoning.—A phylloxera-infested root was immersed by its extremities in a 0·125 per cent. solution of potassium cyanide with the precautions necessary to hinder the phylloxera being exposed to prussic acid vapours. After ten minutes' treatment the adult phylloxera, the nests of which were sunk in the tissues of the root, were dead, the greater number of the larvæ were alive. The cyanide can thus poison the sap, and in that way reach the phylloxeras fixed on the roots. Mouillefert having shown that potassium cyanide acted in a very poisonous manner on the phylloxera, and that an infinite quantity killed these insects either by contact or by poisoning the sap, the substance may be regarded as of great service in agriculture.

1. *Experiments on Phylloxera-infected Vines*, in pots containing 3 litres of earth, on 10 July. A dose of 150 milligrammes of KCN in 400 cubic centimetres of water (a 0·0375 per cent. solution) gave a complete result without injuring the vine, whilst a dose of 500 milligrammes in 500 cubic centimetres water caused it to suffer greatly. A dose of 1 gramme in the same amount of water killed it.

2. *Experiments on Vines in Vineyards*, made on 6 July. The stocks were stripped to a depth of about 15 centimetres, with a radius of 30—35 centimetres (12—14 inches), the soil being rather dry. After pouring on the potassium cyanide solution the soil was replaced at the foot of the stocks and strongly packed. The dose used varied from 20—50 grammes (307—767 grains) per stock, dissolved in 10 litres (2·2 gallons) of water. Wherever the solution had penetrated, the phylloxera and their eggs were dead. But at a depth of 40—50 centimetres (16—18 inches), as well as between the stocks in a radial direction, even by using five times more water the result was incomplete. Trials with the injection method gave no better results, and Mouillefert concluded that potassium cyanide was incapable of producing a complete result in agriculture on the large scale, because its action is only felt where the solution can penetrate. The prussic acid disengaged in the soil cannot diffuse through its layers like carbon disulphide, neither does F. Guerreri believe it possible to use this substance against the phylloxera, for he found that the plant did not resist the doses required to kill it, and that a dose of 1 gramme of cyanide, say 15 grains, per stock was capable of injuring it. Attempts to replace carbon disulphide by potassium cyanide, more especially in Italy, have given unfavourable results.

Disinfection of the Vine.—Whilst potassium cyanide has been abandoned in the different cases described above, this product is used with success to disinfect vines intended for exportation, or coming from a contaminated country This process, introduced at the Nice Agronomical Station by Koenig, yields perfect results. It is in common use, moreover, in Tuscany Sannino advises replacing the disinfectant chambers by baths containing a 0·5 per cent. solution, and in which the vines are immersed in winter for two hours. The same process is used to destroy coccides on fruit trees.

Diaspines (*Diaspineæ*) —Coquillet uses prussic acid as a specific against *Diaspineæ*, coccides (scale insects)

This product may be used against all these dangerous parasites, of which the following are the chief: *Aspidiotus perniciosus*, Comstock (San José louse), injurious to apple-trees in America. *Aspidiotus ostreaformis*, Curtis Oyster scale, very widely distributed on apple-trees, plum-trees, pear-trees, and peach-trees. *Aspidiotus aurantii*, Maskell Coccis injurious to orange-trees. *Diaspis ostreaformis, sign s fallax*, Horvath. Coccis injurious to apple, pear, plum, and peach trees. *Mytilaspis pomorum*, Beché Mussel scale, resembling the preceding and living on same plants. *Lecanium persicæ* (peach kermes), *Lecanium hesperidium* (olive kermes), *Pulvinaria vitis* (vine coccis), *Cereplastes rusci* (fig coccis); *Dactylopius citri* (lemon-tree coccis), *Lecanium amygdali* (almond-tree coccis) American entomologists are unanimous in praising the good effects of the use of potassium cyanide, and that insecticide is in current use in their country. So that the result may be complete, the treatment should last three-quarters of an hour, and the operation done in winter as indicated above.

Earth-worms are less resistant than plants to spraying with a dilute solution of potassium cyanide and they may be got rid of by this means

Small pieces of potassium or sodium cyanide may be pushed into the holes bored in trees by the larva of the goat moth, the holes being then plugged with clay.

The British Ministry of Agriculture recommends that an article sold as potassium cyanide for agricultural and horticultural purposes should be capable of evolving (when treated with an acid) not less than 39 4 per cent. of its weight as hydrocyanic acid

Against soft scale (*Coccus hesperidum*, L)., which infests a wide range of fruit trees in S. Africa, the most satisfactory remedial measure is fumigation with hydrocyanic acid gas, other measures are contact insecticides, such as resin wash or miscible oils, and a soap wash consisting of 1 lb. of soft or hard soap and 8 gallons of water This should be applied warm.

At Porto Rico considerable time has been spent by the entomologist in fumigating tobacco warehouses and factories with hydrocyanic acid gas against *Lasioderma serricorne*, fully 4,750,000 cubic feet of space being treated The warehouses were treated with 40 oz. of sodium cyanide per 1000 cubic feet for forty-eight hours. As a result there has been a considerable reduction in the loss caused by this beetle in cigars.

In the U.S A. serious complaints have been made by nurserymen

and owners of orchards relative to injury to nursery trees when fumigated with hydrocyanic acid gas, and of the factors involved Nearly all admit the effectiveness of the fumigation in destroying scale-insects. It was probably harmless to trees that were perfectly dry at the time of treatment, but it was found impossible always to have the trees in the right condition for fumigation

Fumigation of Ships.—In a paper read before the London section of the Society of Chemical Industry Dr Monier-Williams gave an account of experience gained during two years in the fumigation of ships for the purpose of destroying rats and vermin, with hydrogen cyanide (prussic acid gas). He pointed out that poisoning and trapping can never account for the whole of the rats on a ship, whereas fumigating, if properly carried out, can do so In the past, sulphur dioxide had largely been used, but the United States Quarantine Regulations of 1920 required all vessels engaged in trade with foreign ports to be fumigated every six months This necessitated the fumigation of the passenger quarters of Transatlantic liners, for which purpose sulphur dioxide could not be used, owing to its corrosive action on furnishings and decorations. Hydrogen cyanide was first used in 1890 in the orange orchards of California and Florida; in 1898 it was used by the Cape Government Railways for bugs and lice in sleeping carriages, it was used in India by Col Glen-Lister in 1899 and in quarantine work in Porto Rico in 1910. Since the war, the use of HCN became general, especially in American, Australian, and Italian ports. Discussing the properties of hydrogen cyanide, Dr Monier-Williams said that the toxicity of it is not so great as was formerly imagined, and possibly 1 part in 10,000 of air, or even a higher concentration, could be breathed with impunity. At the same time, beyond 1 part in 2000 of air its action was rapid, and 1 in 500 would probably kill a man instantly. HCN, however, is not an irritant. There was not much smell and the critical point is not easy to recognize. Thus the precautions necessary were more elaborate than with SO_2, and the great essential of fumigating by this method is the most careful organization of the work. The various methods by which HCN can be used were described, the simplest being to place tubs in various parts of the ship containing $1\frac{1}{2}$ parts by weight of sulphuric acid to 1 part of water, and to hinge, on the sides of the tubs, boxes containing solid cyanide, these boxes being tipped up by means of a cord, so that their contents fall into the tubs and so cause the liberation of HCN. Accidents have occurred in foreign ports by the use of HCN, but mostly through negligence in adopting the most ordinary precautions Among other methods is a solution method in which the cyanide is previously dissolved in water and the solution poured through funnels on deck through rubber hose pipes leading to the tubs below, and on the whole it was suggested that this is preferable

Potassium Sulphocyanide, KCNS.—**Preparation.**—Sulphocyanides are produced by the action of sulphur, or a body capable of producing sulphur, on cyanides Potassium cyanide, or even yellow prussiate, fused with sulphur is converted into potassium sulphocyanide thus: 46 grammes of yellow prussiate are heated to pasty fusion with 17 grammes of potash and 32 grammes of sulphur; after cooling, the

mass is crushed, treated with boiling alcohol, filtered, and evaporated

Properties.—If sulphocyanide has certain analogies with cyanide it is far from being as poisonous It paralyses the action of the heart (Cl. Bernard and Pelikan)

Action on Plants.—Mouillefert treated several plants with KCNS —

(1) *Experiments on Adventitious Plant Weeds*—In a space 16 inches square on which there were young plants of *Mercurialis annua*, *Amaranthus blitum*, *Senecio vulgaris*, *Sonchus oleraceus*, *Polygonum aviculare*, Mouillefert placed in six holes, 6 grammes, say 91 grains, of KCNS, dissolved in a litre of water (6 parts in 1000). Next morning all the young plants were dead The adult plants had suffered greatly.

(2) *Experiments on Healthy Vines in Pot*—Half a gramme of KCNS in 250 cubic centimetres of water (1 in 500) and spread round the stock killed it in five days. KCNS thus has a very injurious action on plants, an action almost equal to potassium cyanide As it does not act by its vapours, its action on the plant depends solely on the permeability of the soil for its solutions This explains why equal doses do not always produce identical effects. The same applies to aqueous solutions of all stable salts. Kranch treated barley with $(NH_4)CNS$, and found that a 1 per cent solution killed this plant

Action on Fungi.—Sulphocyanides do not act like cyanides (Hitchcock and Carleton). A 1 per cent solution used in immersion for twenty-four hours did not prevent the uredospores of *Puccinia coronata* from germinating.

Action on Insects.—Mouillefert treated phylloxera-infected vines with a dilute solution of KCNS. An infected pot plant was watered with the dose recognized as capable of killing the vine, say 0 5 gramme, dissolved in 250 cubic centimetres of water Whilst the vine was poisoned the phylloxera were uninjured. Sulphocyanide, very energetic on plants, is thus with the same dose without action on the phylloxera and cannot be used against it.

CHAPTER VIII

BARIUM CHLORIDE—BARIUM SULPHATE—BARIUM CARBONATE—BARIUM SULPHOCARBONATE—CALCIUM OXIDE (QUICKLIME)—CALCIUM SULPHIDE—CALCIUM CHLORIDE—CALCIUM CHLORO-HYPOCHLORITE (BLEACHING POWDER)—CALCIUM SULPHATE (GYPSUM, PLASTER OF PARIS)—CALCIUM SULPHITE—CALCIUM CARBIDE—CALCIUM PHOSPHIDE—CALCIUM ARSENITE—CALCIUM ARSENATE—CALCIUM CYANIDE

Barium Chloride, $BaCl_2$.—**Preparation.**—By treating barium carbonate (Witherite) with dilute hydrochloric acid Carbonic acid is given off and barium chloride crystallized as small rhomboidal lamella formed with two molecules of water of crystallization.

Properties.—Barium chloride is soluble in water, 10 gallons of water dissolve 45 lb. at 15° C. Its taste is sharp It is so poisonous that 4—5 grammes, say 60—75 grains, according to Parkes, kill a man, on whom it first induces general weakness, then paralysis.

Action of Barium Chloride on Plants.—When plants are watered with barium chloride in 0 05—0 5 per cent. solution, chlorosis is induced and lesions occur on the roots. This action is more pronounced the younger the plant, and likewise varies with the nature of the plant. Barium chloride behaves like common salt and like carbonate of lime.

Action on Insects.—It appears to be very poisonous to insects. Absorbed with food this salt kills them as rapidly as arsenical preparations.

Use against Plant Diseases.—Maravek recommends 2 per cent. solutions to kill injurious insects. G Staes uses it with success against the ravagers of young beets, and especially against the altises which sometimes completely devour the young leaves. Young plants support a few days after sprouting a 2 per cent. solution of $BaCl_2$, and when in leaf a 3 per cent. solution. Three sprayings kill coleopterous parasites. Mokezecki recommends spraying with $BaCl_2$ to destroy the grub of the following ravagers: *Anisopterix æscularia*, Schiff.; *Hibernia marginaria*, Bk.; *H. defoliaria*, *Cheimatobia brumata*, L.; *Uropus ulmi*, *Himera pennaria*, *Phlacetonodes sticticalis*, and *Hyponomeuta malinella*, Zell. They recommend the use of this salt according to circumstances in 1½ to 2—3 per cent solution, adding 12 per cent. of sodium carbonate to give adherence to the liquor by the resulting barium carbonate. The action of this product on the grubs makes itself felt after four hours, whilst emerald green under similar conditions requires twenty-four hours to act. This poison, very deadly to grubs and insects, would appear to be harmless to the plants treated, for neither the leaves nor the fruit appear to suffer in contact. It is, however, costly and very

poisonous; it must, therefore, be used with great caution, especially on meadows used as pasture for domestic animals.

Weevils.[1]—Still recommends $BaCl_2$ to kill them

Peritelus griseus (vine weevil).—Stromer remarks its presence on the hop, and recommends spraying with $BaCl_2$ solutions to kill it.

Phorodon humuli, Schrank (hop aphis, green-fly).—Metzger kills this louse by spraying with 1 per cent solutions of $BaCl_2$. The results obtained have been very satisfactory, and he regards this salt as more efficacious than extracts of quassia As aqueous solutions of $BaCl_2$ want adhesiveness, Metzger recommends a paste of 2 per cent of barium chloride and 1·5 per cent. of soft soap Eight days after treatment the aphides had entirely disappeared

Against *Pteroneus ribesii* successful spraying has been done with a 2 per cent solution of barium chloride The addition of 1 per cent of lime was found convenient to indicate the area treated.

Poison-baits are very effective against millipede, *Blaniulus guttatus*, Gerv., if the bait is pieces of potato previously soaked for half an hour in a 5 per cent. solution of barium chloride or in a ½ per cent. solution of arsenic.

Rodents—Barium chloride acts on rodents like carbonate of baryta. To exterminate them Hilner places bread dipped in barium chloride in their runs.

Barium Carbonate, $BaCO_3$—**Preparation.**—By precipitating solutions of barium chloride by carbonate of soda. The natural carbonate (Witherite) is not used as such.

Properties.—Poisonous, insoluble in water

Use.—Largely as poison for the rodents which ravage cultivated land. One pound of bread is mixed with ¾ oz. of sugar and ¼ lb. of precipitated carbonate of baryta, the mass is kneaded and then divided into about 2000 pills (Ressler). One lb. of barley meal is kneaded with ¼ lb. carbonate of baryta and the amount of water necessary to make a stiff paste and divided into pills and laid in their runs (Crampe).

Barium Sulphocarbonate, $BaCS_3$—**Preparation.**—By treating a concentrated solution of barium monosulphide by carbon disulphide, solid barium sulphocarbonate is deposited.

Properties.—Barium sulphocarbonate is a yellow salt slightly soluble in water and resists the action of the carbonic acid of the air for some time, it is more stable than alkaline sulphocarbonates, but it is equally poisonous to plants, and has equal powers as an insecticide

Use.—*Phylloxera vastatrix*, Planch (phylloxera of the vine).—Mouillefert examined its effect compared with alkaline sulphocarbonates. Two vines were stripped down to the large roots and treated with 75 grammes (2½ oz) of barium sulphocarbonate, the first was not watered in any way, whilst the second was immediately watered with 6·5 litres of water, say 1⅛ gallons. With the latter the result was perfect, whilst on the roots of the first a large number of undestroyed parasites were

[1] CURCULIONIDES (weevils)—Coleoptera characterized by a prolongation of the anterior part of the head called the beak or rostrum, the form of the body is bomb-shaped, for the elytra always surround the lower part of the abdomen. The larvæ are polyphagous, they live in the interior of the vegetable tissues (fruits, roots, stems, buds, seeds).

found Barium sulphocarbonate exists a long time in the soil without decomposition, and if not dissolved by heavy rain its action is too slow, and is not transmitted to the deep roots. The latter are not therefore surrounded by a sufficiently poisonous atmosphere to kill the phylloxera and the results are bad.

Calcium Oxide (Quicklime), CaO —**Occurrence.**—Widely in nature, chiefly as carbonate, sulphate, silicate, and phosphate of lime.

Preparation.—Quicklime may be made from carbonate of lime, either in the pure state as marble or chalk, or impure as marl or limestone. Limestone is burnt in lime kilns by heating it gradually to a red heat. This heat, kept up for three days on an average, decomposes the limestone into quicklime and carbonic acid.

$$CaCO_3 = CaO + CO_2.$$

As soon as the burning is finished and the mass cooled, it is packed in casks, and hermetically sealed so that the air does not affect it by its carbonic acid and moisture

Properties.—Lime is converted by the action of water into hydrate of lime ($CaOH_2$) or slaked lime. In slaking, the lime gives off much heat and swells or increases in bulk In contact with carbonic acid calcium hydrate is converted into calcium carbonate ($CaCO_3$). Milk of lime exposed to the air does not keep more than two to three months, and gradually loses its caustic properties Lime is very slightly soluble in water, which only dissolves at the ordinary temperature 0·14 per cent.; hot water only dissolves 0·1 per cent. Lime stirred up with water remains suspended, and forms a milky liquid, "milk of lime." This milk is the fatter, the more pure the lime from which it is made. There are two sorts of lime, fat lime and thin lime The first comes from the burning of almost pure limestone, such as chalk or marble; it is white, and gives off much heat on slaking and increases two or three times in bulk, it forms with water a fatty and binding paste. Thin lime, on the other hand, is produced by the impure limestones referred to above, it is grey, and disengages little heat on slaking, mixed with water it hardly swells and forms a short paste. For agricultural purposes, and particularly for agricultural medicine, it is necessary to choose a fat lime, which yields on slaking a very caustic impalpable powder, which, stirred up with water, yields a milk with great adherence. To increase this still more, a little cement, bullocks' blood, potters' clay, or cow dung is added The white colour, often too glaring, is subdued by stirring a little lampblack into the milk of lime.

Action on Plants.—Milk of lime is a strongly alkaline product which behaves to plants like alkaline liquids, that is to say, it injures the young buds but is without action on the adult organs. Cellulose is not attacked by lime, so milk of lime may be used with impunity in spraying on the different parts of adult plants, and the strength of this milk of lime may be increased at will. There are, however, some exceptions Sorrel, for example, does not stand its action; the same applies to mosses and lichens, the growth of which requires much moisture, are quickly destroyed by lime and especially by quicklime.

Use against Fungi.—Alkaline substances have a decided but weak

action on fungi spores This property was utilized in the beginning of last century to destroy the spores of smut and bunt, at that time no substance fit to render the same service was yet known, and lime was officially recommended by the (French) Government although it had not given very complete results. The chief advantage was that the method did not injure the seed. However, Phillipar found that after this process had been applied, and although all the grains were uniformly covered with lime, the resultant crops still gave 260 bad ears per 1000. Girardin likewise found 112 bad ears per 1000 after macerating the seeds for twenty-four hours in 1 per cent milk of lime Loverdo believes that this bad result is due to the cellulose nature of the exospore of the *Ustilagineæ* which opposes a resistance to the alkaline action of lime According to tests by Kuhn the spores of the bunt of wheat, *Tilletia caries*, resist milk of lime for five hours, but after twelve hours' immersion they have lost their vitality. Bolley does not believe in lime as a disinfectant. Slaked lime in powder had no appreciable action, but immersion for twenty-four hours in a milk of lime gave a result especially on addition of a certain amount of common salt. The following, according to Mathieu de Dombasle, is the comparative result of this treatment (bad ears in 1000) carried out in various ways: Blank wheat, 486. Wheat covered with lime powder, 476. Wheat moistened with milk of lime, 260. Wheat immersed for twenty-four hours in milk of lime, 21. Wheat immersed for twenty-four hours in milk of lime of 2 5 per cent. strength and 4 per cent. common salt, 2 The effect of lime is thus very perceptible, but as soon as common salt or sulphate of soda is added the effects are much more complete. Lime is not now used alone to disinfect cereal grains, but is an indispensable aid to this treatment. Its chief *rôle* is to neutralize the disastrous effects of the poisonous salts on the germinative capacity of the seed and to fix the anticryptogamic products in an insoluble form on the surface of the seeds. By treating with milk of lime seeds which have been steeped in a solution of blue vitriol, the action of which is very injurious to the vitality of the seeds, this salt is converted into copper hydrate. The latter, mixed with sulphate of lime, forms round the grains a deposit of preservative matter, so little soluble as not to be washed away by the water in the soil and capable of preventing the germination of the spores adherent to the surface of the grain as well as the invasion of filaments of bunt which might be present in the soil. The spores of *Phytophthora infestans*, de By. (potato disease) resist milk of lime; the latter is incapable of arresting the development of that disease Rust of wheat likewise resists the action of lime even in heavy doses and in mixing it with equal parts of sulphur

Hitchcock and Carleton have, however, found that lime paralysed the growth of the uredospores of *Puccinia rubigo vera*, Wint. (rust of wheat). But lime has no effect on *Hypomyces perniciosus*, Magnus, mole disease of the mushroom. Used to combat the *Guignardia Bidwelli*, Viala et Ravaz (black rot of the vine), lime gives fairly good results. Galloway obtained by this method an appreciable diminution of bad seed: on the untreated plot 45 per cent. of diseased seed, on the limed plot only 20 per cent. of damaged grain. Debray also regards the liming of the vine as a cure for *Gloesporium ampelophagum*, Sacc.

(grape rot), *Botrytis cinerea*,[1] Pers (the noble or grey rot of the vine) Sorauer advises to spread quicklime on the grapes in autumn as soon as this mould appears

Gummosis of Stone Fruit Trees [2]—Sorauer advises liming the ground strongly around the trees attacked by this disease so as to render the soil drier and warmer, an essential condition in counteracting this disease Wiesner regards this diseased condition of the trees as due to the development of a special ferment, a species of diastase Be that as it may, a good result is obtained by spreading lime in the autumn at the foot of the trees. If the trees in a moist soil suffer from canker or rot of the roots, the roots must be stripped, lime spread between them, and the soil drained. This treatment leads to a perceptible improvement in the diseased condition of the tree.

Rhizoctinia violacea, Tul. (rhizoctinia of the beet) —Frankel recommends to spread slaked lime in powder on the fields to diminish the number of parasites Here again lime only acts directly as on mushrooms by changing the conditions favourable to their development; it arrests their growth and imparts to the plant by converting the humus into assimilable matter the capacity to resist disease better. Unfortunately it is alleged that lime, whilst it diminishes the amount of these parasites, favours the development of other and not less formidable beet diseases, *e g.*, *Phoma tabifica*, Prill. and Dela. (disease of the petioles of beet leaves). The alkalinity of the medium in a wet soil exerts a generally favourable influence on the development of the bacterian diseases of plants. Some authorities regard lime as favouring potato scab considerably. To reduce these diseases it is on the contrary useful to render the medium acid, say by green vitriol or by "sulpharine," which contains 15 per cent. sulphuric acid.

Ophiobolus graminis,[3] Sacc. (*Pietin*), (disease of wheat stalk).—Sance advises as a cure to sow by hand 176 lb. of quicklime per acre as soon as the disease appears. Marenghi recommends quicklime as a preventive; he advises to spread 3—4 cwt. per acre and to harrow the ground slightly afterwards.

Tobacco Leaf Spot —Van Os, to prevent this disease, ploughs in

[1] BOTRYTIS CINEREA (grey rot of the vine) *Vine Sclerotinia*.—In a humid and warm medium this fungus, generally saprophytic, attaches itself to the leaves and the young buds of the vine, the young bunches of grapes may, likewise, be attacked at the time of flowering; but it is chiefly when the grapes are half-grown that the packed and compact grapes are destroyed by this fungus. The grapes attacked first assume a dirty tint, their surface tarnishes, they wither and become covered with a velvety grey which characterizes this disease. When the *Botrytis* develops only on ripe grapes it causes no damage; it then improves the quality of the wort. The green mould does not attack the vine alone. On a number of plants on which at the outset the stems are seen to become brown, fade, and wither without apparent cause, the medulla contains *Sclerots* which produce conidiophores of *Botrytis* covering the damaged organs with an ashy, velvety grey.

[2] GUMMOSIS OF STONE FRUIT TREES (cherry leaf spot) —The fungus *Coryneum Beyerinckii* is regarded as the chief cause of the gum of stone fruit trees, known under the name of spot of stone fruit trees

[3] OPHIOBOLUS GRAMINIS (disease of the lower part of the stem of wheat) —Laid wheat is due to the invasion of the winter nodes nearest the soil by a fungus which, in damaging the stalk at the level of the soil, is often the cause of the laying of the straw of cereal crops. The mycelium develops in the interior and the exterior of the tissue.

11 bushels of quicklime per acre. He thus brought down the proportion of diseased plants to 7 per cent, whereas it was 100 per cent. in the unlimed plot.

Plasmodiophora brassicæ, Woronine (finger and toe).—Lime is an excellent means of preventing the spread of this fungus. Nijpels advises to mix the infected soil with half a litre of lime per square metre. Seltensperger applies the following treatment: During and after transplanting there is deposited at the foot of each cabbage in a sort of deep cup, of 6—10 centimetres, made for the purpose, a big handful of quicklime which is covered with earth to the level of the surface. Of 600 cabbages and cauliflowers treated thus none were attacked by the disease, whilst the untreated plot was seriously compromised, 25 per cent. of the cauliflowers and 50 per cent. of the cabbages were attacked. Halstead who advises this treatment in America believes that it has a preferable effect on plants to that of Bordeaux bouillie, corrosive sublimate, blue vitriol, kainite, but it is necessary to use at least 2 tons 8 cwt. per acre.

Use of Lime against Nematodes.—Lime in strong doses is a cure for these worms. Lime spread on the surface of the soil changes its characters entirely. The humus (mould) sought after by these worms being transformed the soil does not any longer present the conditions essential to their growth. The evolution of the nematodes is, moreover, arrested by the alkalinity of the soil. Although lime, and especially quicklime, may disinfect the soil and thus improve certain crops it cannot replace carbon disulphide, which according to Girard destroys more surely all the nematodes in a field.

Heterodera Schachtii, A. Schmidt (nematode of the beet).—Hollrung found this nematode very sensitive to the action of lime, and that by mixing 1 part of quicklime with 4—6 parts of soil these nematodes were destroyed. Kuhn advises applying the lime in autumn, as in that way whilst diminishing the number of nematodes the lime transforms the humus into assimilable matters and enables the more vigorous beet to reconstitute its radicular system attacked by the parasite.

Tylenchus devastatrix, Kuhn.—The liming of seed-corn is without effect against these, and disinfection does not diminish this disease, as the insects are polyphagous and even saprophytic. These insects live on the most diverse plants, causing very different diseases, chiefly on onions, clover, potatoes, poppies, etc. Weiss advises to burn the stems after harvest and dust the fields with quicklime and apply mineral manure in abundance in the springtime.

Use against Insects.—Few insects are sensitive to the alkaline action of lime, yet those with soft skins and delicate larvæ do not resist milk of lime or powdered quicklime, which they particularly dread. Lime thus forms an excellent medium for fighting these parasites. But in most cases lime has only a mechanical action on the spot occupied by the insect.

Perroncito's experiments on the eggs of *Bombyx mori*, L., have proved that milk of lime cannot kill the latter, for the eggs of this bombyx are capable of being perfectly hatched after steeping in milk of lime for twenty-four hours. In spite of this harmlessness, milk of lime is used in arboriculture, for the lime-washing of the trunks is an

excellent method of diminishing the number of these parasites. The previous cleaning of the trunks removes all moss, lichens, and bark which formed so many refuges in which the insects and their larvæ pass the winter and eggs are laid. It plays as great a *rôle* as the liming itself. All the hiding-places preferred by these parasites are destroyed, and not knowing where to deposit their progeny they are obliged to seek refuge elsewhere. Against coccids lime exerts a special mechanical action; their shell, covered by a thick layer of lime, is, owing to the contraction of the lime, detached from the branch on which it was fixed, thus causing death.

Liming of Trees.—This practice advised by Blanchère is a very good one for it frees the trees well from parasites. The strength of the milk of lime may be increased to a thick paste without injuring the tree. To secure good disinfection it is better not to use milk of lime alone but mixed with tar and naphthalene as advised by Balbiani. To complete the work of liming it is well to collect and burn all the broken particles of bark and to bury with quicklime all the fallen fruit. As it slakes the lime destroys the parasites by the heat given off. By this means the number of anthonomes, cheimatobias, and even *Schizoneura lanigera* (woolly aphis) are greatly diminished. The results will be more complete the more regularly the liming is repeated.

Lime wash for fruit trees (British Ministry of Agriculture formula). Best stone quicklime 10—15 lb., water 10 gallons. Slake the lime with a little water, add the rest of the water, with thorough stirring, and strain carefully into the spraying machine.

Scolytides.[1]—The Bostrichi and the Hylesini, injurious to conifers, the scolytides, injurious to deciduous forest trees, cannot be destroyed by liming the trunk, but regular whitewashing with lime may remove them. Again whitewashing with thick and pliant lime in autumn after scraping the tree stops the exit orifice of the scolytides and renders the bark less accessible to the female in winter. Robert advises summer liming. If during summer a tree is badly infested by these insects there must be no hesitation in making longitudinal cuts or a surface barking, taking care immediately afterwards to coat the wound or the trunk with milk of lime. But when the tree is too far gone it is preferable to fell it and burn it, taking care to protect all the adjacent trees by liming or with the coating described further on. This operation, extensively applied in Austria, consists in painting the trunks and even the branches with a mortar made thus: Macerate 5½ lb. of tobacco in 1·1 gallons of hot water kept at a rather high heat, add 11 lb. of ox blood, and 11 lb. of lime and cow dung to a pasty consistency. The trunks and branches are coated several times with this composition until a hard weather-resisting coat is formed.

Amongst the better-known scolytides there may be quoted *Eccoptogaster pruni*,[1] Ratz. (scolytus of the plum). *E. regulosus*,[1] Koch.

[1] SCOLYTIDES.—The scolytides are small-sized Coleoptera, which the number and nature of their depredations render very injurious to forest and fruit trees. They bore holes of various shapes, for the most part between the bark and the wood, in which the female lays its eggs. The larvæ bore secondary holes, which sometimes penetrate directly and deeply into the wood. SCOLYTUS OF THE PLUM. *Scolytus pruni.*—It ravages plums and apple-trees. The foliage of the invaded trees is scanty, their growth is sickly, and they do not yield fruits.

(rugose scolytus). *E. Scolytus*, Ratz (elm scolytus). *Hylesinus oliperda* (hylesinus of the olive-tree, cirai, taragnon). *Tomicus ficus*, Er. (bostrich of the fig) *Tomicus mori*, Aub. (bostrich of the mulberry) *Bostrichus dispar* [1] (apple bark beetle), Hllw, and *B. saxesini*, Ratz, both injurious to fruit trees All these scolytides may be removed by the above treatment.

Colaspidema ater,[2] Ol (negril) —Debray recommends the liming of lucerne the moment the young larvæ commence their inevitable invasion, but, so as not to be forced to lime all the field of lucerne, it is well to mow it prematurely and only leave a small strip of lucerne where all the larvæ will take refuge, this strip is then limed.

Anthonomus piri, Boh (anthonome of the pear); *A. pomorum* (apple blossom weevil) —Poubelle limes the trees in autumn with a mixture of lime 22—33 lb., flowers of sulphur 22 lb, gelatine 6 6 lb., the whole mixed with water to a thick paste which is spread on the trunks after removing the moss

Haltica ampelophaga, Geur (altise of the vine) —The green altise which ravages the leaves of the vine may be destroyed by projecting powdered lime on to the vines (Audibert)

Crioceris asparagi, L. (asparagus beetle).—Vial advises dusting the asparagus with impalpable slaked lime, preferably in the morning dew.

Agriotes lineatus, L.—If lime is not directly injurious to the larvæ of this insect spread on the fields, it helps greatly to diminish their numbers. According to Schilling, annual liming yields still more complete results This improvement is due to the transformation effected by the lime on the soil, which after having been wet and charged with humus favourable to the evolution of the larvæ becomes drier after liming and unfit for their development.

Gryllotalpa vulgaris (mole cricket).—In Italy this orthoptera is removed by liming at the rate of 16 cwt. to the acre

The larvæ of some Hymenoptera are very sensitive to lime

Ptereneus ventricosus, Kl, *N. ribis*, Scop. (the gooseberry and currant saw-fly) —Lime in itself forms a good means of destroying their larvæ. Firor, however, prefers a mixture of 4·4 lb of lime and 2·2 lb. of powdered tobacco which he spreads on the shrub after moistening it.

Selandria (*Eriocampa*) *adumbrata*, Kl (slimy caterpillar, slimy larvæ of pear saw-fly).—Lime forms an excellent means of destroying this sticky larva which skeletonizes the leaves of the pear.

Amongst the Lepidoptera a few may also be combated by lime The large white garden butterflies are destroyed by dusting freshly slaked lime on plants and then watering them (Vial).

Cheimatobia brumata, L. (the winter moth, Evesham moth), *Sesia*

SCOLYTUS (RUGOSE). *Eccoptogaster regulosus*—It preferably attacks small branches and limbs. The perforated parts of the tree turn yellow and die Plum-trees are especially chosen by it

[1] BOSTRICHUS (BORCIS)—Small Coleoptera belonging to the family of the Scolytides, distinguished by their cylindrical and bomb-shaped body, by their thick head drawn back into the thorax

[2] COLASPIDEMA ATER.—Black lustrous, 3 millimetres long. The colaspidema is a plague of the lucerne fields of the south of France.

myopiformis, Bkl. (sesia of the pear), *Grapholitha Wœberiana*,[1] W V — The liming of the trunks prevents the females of these butterflies from depositing their eggs. The caterpillars of the last two butterflies may be destroyed by plastering the trees with a thick milk of lime mixed with clay (Taschenberg) and applied at the time the caterpillar is making its ravages

Tingis piri —This *Hemiptera* has been successfully combated by lime, which ought to be applied as a whitewash in February. The *Homoptera* have likewise been fought by lime with more or less success, for here again it is still by its desiccating properties that it especially acts. By using milk of lime as thick and hot as possible the contraction of the lime detaches the coccides and kills them at the same time But a good result is not obtained unless care is taken to prune the tree and clean it from top to bottom. Thus cleansed and covered with a layer of lime the tree is not attacked by coccides, and the fumagine (fruit tree smut) which only lives on the dejections of these insects is avoided Liming is thus an indispensable operation in arboriculture and it gives good results if renewed each year.

Coccus vitis, L (red coccis of the vine, vine scab) —Winter is the best time to attack coccids, for that is the time that these insects get on to the trunks to lay their eggs. Bellot des Minières advises after pruning to clean the trunk completely, including scraping and careful barking It is then whitewashed with lime, which protects it against these insects

Aspidiotus perniciosus, Comstock (San José louse).—To combat this coccis the Americans replace lime by a mixture of salt, sulphur, and lime, sold as " salt lime and sulphur wash." Applied in winter on the trunks of trees this mixture forms a hard crust which prevents the reproduction of this insect (see below, p 158)

Schizoneura lanigera, Hausmann (woolly aphis).—Muller advises coating the ulcerated spots infested by this aphis with milk of lime after having completely cleaned them. To destroy the woolly aphis, which live underground around the stock and the roots, Goethe advises to strip the trees in autumn or winter to a depth of 2 feet, and water them copiously with milk of lime. A layer is then made 3 centimetres, say 1·2 inches, thick of quicklime, then the earth is covered in. Taschenberg finds this method very efficacious. To combat *green lice*, Arbringer advises liming the whole tree in winter or spring If an insecticide be added to the lime, such as tar or naphthalene, success is complete, for in that case the eggs of the louse are killed at the same time as those of the most diverse insects. Balbiani's mixture, as well as milk of lime, is incapable of preventing the opening of the buds, which are thus protected against insect attacks.

Limaces (snails) are also killed by lime. If it is a case of destroying snails on plants, freshly slaked lime is blown on to them from a bellows. Each snail touched dies forthwith. The best time for this operation

[1] GRAPHOLITHA WŒBERIANA (tinea of stone-fruit trees); TORTRIX (*Carpocapsa*) WŒBERIANA —The caterpillar of this microlepidoptera perforates the bark of plum-trees, peach-trees, apricot-trees, and almond-trees, penetrates into the alburnum and there undergoes metamorphosis. It kills the bark by the wounds it produces; it causes canker and a flow of gum. It prefers the peach and the plum.

is early in the morning, or in the evening a little after fall of day In vineyards, the buds are protected against small snails by spreading slaked lime in powder on the stock, and laying a train of lime, 7—8 inches, around each stock In the fields, lime is shown by hand at the rate of 25—30 bushels of slaked lime per acre In destroying snails lime spread as an impalpable powder gives the best results. The operation is repeated several times if it is desired to reach all the snails Lime used against snails tends to be replaced by nitrate of soda, tobacco powder, but especially by a 3—4 per cent solution of blue vitriol. This solution is sprayed on the plants at the time the snails are on their rounds, the snails which are attacked die immediately and those which pass on to a branch covered with blue vitriol are likewise poisoned

Use against Mammals.—According to Taschenberg, plants are preserved from rabbits, hares, deer, by coating with lime It is preferable to add strong smelling substances, such as petroleum, aloes, lard (rubbing a skin of lard against the trunks of 100 trees suffices) To impart more adherence and thickness to this paste, it is well to add cow dung and thin it down with purin Seed can be protected against mice by coating them with a thick milk of lime and spreading petroleum thereon. They are then sown immmediately after this treatment. Such seed are not attacked by rodents.

Late Frosts.—Lime is successfully used against late frosts. When frost is to be feared, slaked lime in powder is spread on the buds of vines and fruit trees from a bellows so as to cover all their surface. These buds well covered with lime will not be attacked by the frost nor burnt by the sun striking them afterwards. With fruit trees it is necessary to operate before the blossoming of the flowers, or after fructification has taken place.

Calcium Monosulphide.—Preparation.—(1) By heating lime in a current of sulphuretted hydrogen, (2) by heating a mixture of sulphate of lime and charcoal, (3) by boiling milk of lime with sulphur; the polysulphides are so prepared, but by using larger proportions of sulphur. The product obtained by boiling milk of lime with excess of sulphur is called *calcareous liver of sulphur*. The paste bouillies employed to combat plant diseases are of very diverse compositions, and contain either a basic monosulphide or a monosulphide or polysulphides of calcium. They are generally prepared by boiling a milk of lime with flowers of sulphur, until the latter is completely dissolved. After cooling there are incorporated as occasion requires very diverse substances, such as glycerine, soft soap, copper salts, naphthalene, etc. To prepare and preserve these pastes, enamelled vessels are used The bouillie recommended by Mohr is the one most in use It is made thus: 22 lb. of quicklime are slaked, then made into a milk of lime and run through a sieve, on the other hand, 11 lb. of flowers of sulphur are stirred into 2·2 gallons of crude glycerine; the two liquors are mixed and the bulk made up to 22 gallons of liquid which is boiled for one hour over a small fire. A concentrated solution is thus obtained marking 18—20° Bé., which is appropriately diluted when required for use, to suit it for particular purposes, with 10—12 parts of water. It is best to dilute it with a milk of lime of 0·5 per cent. strength Crouzel's anticryptogamic is prepared thus: 14 oz. of lime are slaked and the milk of lime

therefrom run through a sieve, 35 oz. of sulphur added and the whole completed with water so as to produce 150 oz of bouillie When a homogeneous mixture is obtained, it is brought to the boil for an hour, care being taken to replace the water evaporated. The solution is filtered or decanted; it marks 20° Bé , 0 1 oz. of naphthalene is added and 2 oz. of hyposulphite of soda, and the whole completed with water to 100 gallons. This preparation is used as it is against the cryptogamic diseases of the vine

Numerous methods of preparing lime-sulphur wash, as followed by practical orchardists, have been investigated by the U S Bureau of Entomology, or tested by it in the course of its experimental work. The following formula and method of preparation have uniformly resulted in a satisfactory wash, and are quite simple —

Lime	20 lb.
Sulphur (flour or flowers)	15 lb
Water to make	50 galls.

Preparation —Heat in a cooking barrel or vessel about one-third of the total quantity of water required. When the water is hot add all the lime, and at once add all the sulphur, which should previously have been made into a thick paste with water. After the lime has slaked, about another third of the water should be added, preferably hot, and the cooking should be continued for an hour, when the final dilution may be made, using either hot or cold water as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the start, but subsequent stirring is necessary if the wash is cooked by direct heat in kettles If cooked by steam no stirring will be necessary After the wash has been prepared it must be well strained as it is being run into the spray pump barrel, or tank

The ingredients of the wash, in proper proportion, are boiled together in water, by which means chemical action between the lime and sulphur is brought about, producing in solution the insecticidal properties of the wash, the extent of chemical action depending directly upon the length of time cooking continues From 45 minutes to an hour of vigorous boiling will put practically all of the sulphur into solution, and preference should be given to the latter period. A properly cooked wash is a heavy, caustic, orange-yellow liquid, with a strong sulphurous odour Upon standing, the sediment settles to the bottom, leaving the liquid relatively clear.

A highly concentrated lime-sulphur solution may be made by using the lime and sulphur at the ratio of 1 to 2 as is usually recommended, but with reduced quantities of water The formula used in the commercial lime-sulphur manufacturing plants visited and also in the foregoing experiments is as follows :—

Fresh stone-lime	80 lb.
Commercial ground sulphur	160 lb.
Water to make the finished product	50 galls.

While there is about 50 per cent. in volume of sludge after allowing this solution to settle for 24 hours, there is only about 5 to 10 per

cent in volume of insoluble materials These consist of sulphites, free lime, free sulphur, magnesium compounds, etc, varying with the kind of lime used and other conditions. Solutions prepared by this formula should test on an average 33—34° Bé.

The caustic, disagreeable character of the wash is frequently complained of by orchard workers Much may be done to remove the objections to its use by spray gangs by supplying the men with rubber coats and gloves The use of vaseline on the face is advisable in working during windy weather, and clear glass goggles may be used to protect the eyes. Lime-sulphur wash is very hard on the pumps, and these should be thoroughly cleaned at the close of each day's use

Self-boiled Lime-Sulphur-Caustic-Soda Wash—The expense of establishing cooking plants and of their operation constitutes an important objection to the lime-sulphur wash, and some attention has been given by U S entomologists to the devising and testing of washes made simply by the heat generated by the slaking of the lime, or by the additional heat following the addition of caustic soda To prepare this wash, place in a suitable barrel or other vessel 30 lb of good quicklime and start slaking with sufficient hot water to prevent air-slaking As soon as the slaking is well under way add 15 lb. of sulphur previously worked into a paste with water, and stir thoroughly Hot water is added from time to time in sufficient quantity to bring the mixture up to a thin paste. After slaking has ceased add 5 or 6 lb. of commercial caustic soda, stirring until the soda is dissolved. To this should be added sufficient water to bring up to 50 gallons of wash

Properties.—Calcium sulphides are soluble in water, and in all proportions Moistened with water and in contact with air they are rapidly converted into carbonate of lime and sulphuretted hydrogen.

$$CaS_2 + CO_2 + H_2O = CaCO_3 + H_2S + S.$$

But simultaneously with this decomposition they undergo partial oxidation into hyposulphite of lime Calcium sulphides are neutral. They act by the amount of sulphur which they contain To prevent their too rapid decomposition in moist air, various substances have been incorporated, such as glycerine and milk of lime, in the proportions given by Mohr (p. 157), molasses, soft soap, in the proportion of 1—2 per cent These substances also cause the bouillies to adhere better to plants.

Action on Plants.—Calcium sulphides are less injurious to the green parts of plants than potassium sulphides, because their solutions are not caustic. Solutions of glycerinated monosulphide may dry on the leaves without injuring them. But in spite of that it is necessary to avoid the too rapid decomposition of these sulphides for the sulphuretted hydrogen produced is very injurious to the plant; 0·75 per cent of this gas diffused through the air may poison certain plants. The use of glycerine to form bouillies, and of water and lime to dilute them prior to use, helps greatly to attenuate the effect of this gas; by delaying the decomposition of the sulphides, too large an amount of sulphuretted hydrogen is prevented from being formed at one time. The damage

caused to different plants, as well as on the roots treated, is likewise caused by hyposulphite of lime often present in impure calcium sulphides, hyposulphites scorch the leaves especially during strong summer heat Owing to their reducing action sulphides, and particularly calcium sulphides, are injurious to the roots which come in direct contact with it.

Action on Fungi.—The action of calcium sulphide on the mycelium of fungi is in principle the same as that of sulphur, but polysulphides, which are in a way solutions of sulphur, may be looked upon as more active than sulphur, even used in its most impalpable form Whilst sulphur has no radical action on the *Erysipheæ*, the mycelium of which is exposed without any protection on the surface of plants, calcium sulphides act on fungi which live in the plant itself

Action on Insects.—Generally insects are not disturbed by solutions of calcium sulphide. It is otherwise with acari, plant lice, which are easily destroyed by this preparation. Sulphides are, so to speak, specifics against the *Phytoptides* which produce the different *erinoses* of plants and the most diverse galls. Used against these pests their action, otherwise very imperfect, is solely due to the sulphuretted hydrogen given off, which is exceedingly poisonous to these insects.

Use against Fungi.—Calcium sulphides form an efficacious and economic means for the destruction of the most various parasites They are practical substitutes for sulphur. They have in themselves a remarkable action; but it is well to incorporate in their solutions substances capable of protecting them against moist air which renders them inactive too soon and causes them to poison plants. Mohr advises their use against cryptogamic diseases

The British Ministry of Agriculture recommends, against apple mildew (*Podosphæra leucotricha*) and apple and pear-tree scab, also American gooseberry mildew, that lime-sulphur solution sold for agricultural and horticultural purposes should be made from lime, sulphur, and water only. The specific gravity of the solution as sold should not be less than 1 3 at 15° C

The summer stages of the European red mite (*Tetranychus telarius*) are controlled in Maryland on apple trees by the regular spray schedule of lime-sulphur 1 : 40, if the spraying is thoroughly done. If the foliage of apple becomes infested during the summer, a lime sulphur spray diluted to 1 part in 75 parts water is used, with a spreader such as calcium caseinate or flour.

Anarsia lineatella (peach twig moth), a serious pest, particularly of the late variety of peaches, may be kept under control by delayed dormant spraying with lime-sulphur. A dormant lime-sulphur spray applied when the buds are swelling or even opening is recommended against *Eriophyes pyri* (pear-leaf blister mite); a second spray, consisting of one-third the winter strength, should be applied in the cluster bud stage, and just before the blossoms open.

In Nova Scotian apple orchards, against scab and scabby blotch, codlin moth, brown tail moth and aphis most growers spray three or four times, and the best of them five or six times. The first spray consists of lime-sulphur of 1·009 specific gravity or 3 gallons commercial strength to 100 gallons of water (1 to 33), with the addition of arsenate

of lime 2 lb. to 100 gallons This is put on at 200 lb. pressure when the trees are in the green bud stage For the second spraying, just before the blossom buds have opened, weaker lime–sulphur (1 to 43) and arsenate of lime is used. The third spray, after the petals have fallen, consists of lime–sulphur 1 to 50 and arsenate of lime 1½ lb. to 100 gallons Two weeks later the fourth spray is used and this consists of Bordeaux mixture (7 lb copper sulphate, 7 lb quicklime to 100 gallons) with 5 lb paste lead arsenate added to each 100 gallons. In very wet seasons a fifth spray, similar in material to the fourth, is used two weeks later to control apple scab

Cuscuta (dodder)—Carrigon employs calcium sulphide with success to destroy the vegetable parasite dodder in forty-eight hours. To obtain this effect calcium sulphide is spread on the ravaged parts of the field, and these spots sprayed slightly with water The result is especially favourable in wet weather. If this treatment is applied before the maturity of the grain the dodder may be considered as eliminated from the fields.

Peronospora viticola, de By. (mildew of the vine)—Vesque recommends polysulphides against this parasite of the vine A bouillie is prepared for the purpose with 1 lb of quicklime to 3 lb of sulphur in 10 gallons of water The leaves and the grapes are sprayed at the time the vine is usually sulphured.

Erysipheæ (mildews)—All these fungi can be destroyed by calcium sulphides; they act on their mycelium disorganizing them rapidly like sulphur. Their use is, however, more simple, their action more regular, because it does not depend on the temperature which, as regards sulphur, is one of the conditions of success Besides, solutions being spread more uniformly on the organs of the plant attacked the action is more thorough.

Uncinula americana, How (oidium of the vine).—Crouzel recommends his "anticryptogamic" against the oidium, the composition of which has already been given Spraying ought to alternate at five or six days' interval with cupric preparations. Polysulphides employed without naphthalene or hyposulphite produce the same effect, and Mohr's preparation arrests the oidium in full evolution. In the spring 4 per cent solutions of polysulphides are used, 5 per cent. solutions after flowering, and 6 per cent. solutions at the end of summer. The latter do not injure the leaves In the same way as for the oidium, mildew of the vine, the polysulphides of calcium have been used to destroy the following *Erysipheæ* (mildews): *Sphærotheca pannosa* (mildew of the rose and the peach), *Microsphæra grossulariæ*, Wall (mildew of the gooseberry); *Erysiphe communis*, Wall. (mildew of hay and clover). Nijpels recommends to use against mildew of the rose a sulphide prepared thus. boil 100 gallons milk of lime made with 20 lb. of quicklime and 40 lb of sulphur; after twenty minutes' boiling the sulphur is dissolved and the whole cooled. A teaspoonful of this solution per litre of water for spraying suffices, which should be done two or three times during summer.

Capnodium (fumagine)—The fumagine (fruit tree smut) is destroyed by 5 per cent sulphide solutions, but according to Franck and Kruger this product cannot destroy the coccides which produce it.

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Amongst the black-blights there are also some which may be combated with polysulphides: *Gloeosporium ampelophagum*, Sacc. (anthracnose of the vine). Against this disease it is necessary to apply a spraying of sulphide before the flowering of the vine.

Cladosporium fulvum, Cooke (tomato disease).—Mohr particularly advises the use of polysulphides against this disease which act in a more efficient manner than copper salts.

Actinonema rosea, Fr. syn. (*Asteroma radiosum*, Fr.).—Mohr recommends two or three sprayings during summer.

Hypomyces perniciosus, Magnus (mole disease).—Constantin and Dufour found that this disease can be combated by calcium sulphides.

Nectria ditissima,[1] Tul (canker of the pear-tree, canker of the apple-tree, canker of the beech-tree), *Nectria cinnabarina*,[2] Rode (necrosis of wood).—Mohr advises to combat these two parasites with glycerinated sulphides. The wound is deeply incised, cleaned, and then coated several times with a solution of glycerinated sulphide of calcium, titrating 15—25° Bé. When the wound is dried up it is covered with a linseed oil varnish (? boiled oil). To obtain a cure it is sometimes well to repeat this treatment several times a year. It is also recommended to use a concentrated solution of sulphide mixed with a thick milk of lime and to coat the wound after drying with a mastic of some sort.

Fusicladium pirinum, Fuckel (pear scab); *Fusicladium dendriticum* (apple scab).—Mohr advises the use of glycerinated sulphide of lime, of the usual strength, as soon as the fruits have formed and are the size of a pea, two or three additional sprayings being given during the summer.

Hydnes and *Polypores* are combated with calcium sulphides. *Hydnum Schiedermayri*,[3] Heufl., *Polyporus sulphureus*,[4] Fries, *Polyporus igniarius*,[4] Fries (false tinder fungus).—Mohr advises to combat this disease by excising all the diseased wood and to plaster the

[1] NECTRIA DITISSIMA (canker of the apple-tree, the pear-tree, and the beech).—This fungus is the immediate cause of some cankers which gnaw the branches of the apple-tree and the pear-tree. It is one of the most formidable diseases of fruit trees.

[2] NECTRIA CINNABARINA (necrosis of wood; coral spot disease).—This fungus, which generally lives as a saprophyte on dead wood, appears also as a parasite and corrodes the wood. It attacks the horse chestnut, the maple, the ailantus. Its mycelium not only extends into the bark but into the wood itself, it is a parasite of the ligneous body like the *Polypore*, which live at the expense of the starch.

[3] HYDNUM SCHIEDERMAYRI.—This fungus is an apple-tree parasite which rots the wood. It bores the trunk, forming great holes of rot, whence issue in autumn irregularly shaped, yellow, fleshy receptacles, which may reach 5 centimetres (2 inches) in diameter and 10 centimetres (4 inches) thick. They smell of anise.

[4] POLYPORA.—These receptacle fungi form projecting lamellæ either fleshy or ligneous in the form of a bracket or a horse-shoe attached laterally by their base in the interior of which their mycelium is spread. Polypores attack fruit trees. They cause white rot especially of the wood of the oak. POLYPORUS IGNIARIUS (false tinder fungus).—As widespread as *P. sulphureus*, it preferably attacks very old oaks and there causes white rot, but it also shows itself on the beech, the poplar, the hornbeam, the willow, and on fruit trees. POLYPORUS SULPHUREUS (heart wood rot).—This widespread fungus especially attacks the oak, the walnut, the pear-tree, and the poplar. Where it fructifies yellow sulphurous hoods appear rising one above another.

wounds several times with glycerinated sulphide of lime of 20° Bé, then to coat with mastic Mohr also advises to combat certain rusts with calcium sulphide thus *Phragmidium subcorticum*, Schrank (rose rust), and also the rust of the pines and spruces, such as *Chrysomyxa abies*,[1] Unger (rust of needles of Epicea), and others The treatment should be carried out in May so as to avoid fresh infection of the plant *Peridermium pini*,[2] Walr (vesicular rust of the bark of the pine); *Peridermium oblongisporium*,[2] Fuckel (vesicular rust of pine needles).—Mohr advises to combat these diseases with his bouille diluted with 10—12 parts of water. The result it appears is as good as with Bordeaux bouillie

Exoascus deformans,[3] Fuckel (Cloque du Pecher), (blistering, wrinkling, or curling up of the leaves of the peach)—Pierce and Mohr advise spraying with calcium sulphide to prevent this disease; according to these authorities complete success is obtained if, as soon as it makes its appearance on the first leaves, they are sprayed with a 4 per cent. solution

Use against Insects.—*Carpocapsa pomonella*, L (codlin moth, apple worm, pyralis of the apple).—Mohr advises calcium sulphide glycerinated to $\frac{1}{10}$ to prevent apples becoming wormy To prevent the hatching of the eggs laid by the female on the young fruit a first spraying should be made as soon as the fruit is formed or soon after flowering, the fruit should be inspected from time to time and sprayed afresh where required.

Phylloxera vastatrix, Planch (phylloxera of the vine).—Mouillefert tried to determine the action of calcium pentasulphide on this pest by making injections round an infested stock, amounting in all to 350 cubic centimetres, of a solution of 23° Bé. diluted with 7 litres of water [twenty times its volume]. The result was perfect on the upper roots but not complete on the deep roots

Aphides (naked plant lice)—Many observers have recommended 2—4 per cent. solutions of calcium monosulphide and even the same product in the form of powder as a specific against green lice.

Aphis persicæ, Sulz, which is destroyed at the same time as the leaf curl (Exoascus deformans) by a 4 per cent. solution; likewise the *Aphis oxyacantha*, Koch, which causes the cloque of the hawthorn; *Aspidiotus perniciosus*, Comstock (San José louse), *Aspidiotus aurantii*, Maskell (coccis of the orange). The Canadian Government advises for the destruction of these dangerous coccides a bouillie consisting

[1] RUST OF SPRUCE NEEDLES *Chrysomyxa abies*—The young needles attacked in the course of summer turn yellow where the fungus is localized

[2] RUST (VESICULAR) OF THE BARK OF THE PINE *Peridermium pini*, *Pine Cluster Cups*—In May bladders or whitish membranous sacs, which split to let the æcidium spores which they contain, and which form an orange dust, escape, are seen to appear on the pines, chiefly at the foot of the stem of the young plants, or on the branches of adult plants The mycelium extends between the bark and the liber, and sinks into the wood through the medullary rays RUST (VESICULAR) OF PINE NEEDLES. *Peridermium oblongisporium*.—This rust is similar to the preceding, but it is localized in the needles

[3] EXOASCUS DEFORMANS (leaf curl of the peach)—This disease is caused by the complete deformation of the leaves, which thicken, curl, twist, and swell, assuming a pale yellow to rose tint. When the disease reaches a certain pitch, the young branches are also invaded and deformed